A COMPARISON OF MALAYSIAN SECONDARY STUDENTS PERCEIVED EASE OF USE AND USEFULNESS OF DYNAMIC MATHEMATICAL SOFTWARE

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Abstract: *- Technology is becoming important in the lives of school students. The integration of technological tools has been widely practiced in teaching and learning mathematics in order to enhance students' understanding of mathematics. Teaching and learning mathematics can be beneficial through the use of dynamic software. Learning mathematics on computer screens can be some sorts of visual entertainments for students. The teaching process is absolutely no longer about the interaction between the teacher and the students but also it can be the interaction between the student and the software itself. Therefore, institutions should attempt to utilize dynamic software in order to add value to the education process. The use of Geometer's Sketchpad (GSP), Autograph and the Graphing Calculator (GC) had been implemented for the learning of mathematics in Malaysian secondary schools. This paper will discuss how students perceived the ease of use and usefulness of using Autograph and GSP and GC during learning Quadratic Functions. A total of 124 secondary school students in Malaysia participated in the study. They were randomly assigned into three different groups. Each group underwent instruction utilizing either one of the software. Findings showed that students' mean scores of perceived ease of use of the graphing calculator is higher compared to the use of Autograph and GSP. However, there was no significant difference in the mean scores of perceived ease of use and perceived usefulness of the three software. These findings have shown promising implications for the use of mathematical software and graphic calculator in teaching mathematics at Malaysian secondary school level.*

Key-Words*:* - Geometer Sketchpad, Graphic Calculator, Autograph

I INTRODUCTION

The term of information communication technology (ICT) can mean different things to people who work in different sectors. Improvement in the ICT field has resulted in more intensive usage of computers within educational field [21]. In the education sector, ICT can be referred as a way that computers are used as a medium in delivering the information either by standing alone or through the internet. Technology integration has been used primarily to support current methods of teaching especially in mathematics. Use of technology as a tool or a support for communicating with others allows learners to play active role rather than the passive role of recipient of information transmitted by a teacher, textbook, or broadcast [20]. School students need a variety of skills such as problem solving abilities. This type of skill can be acquired through the integration of mathematics and technology. Most students today are more proficient with computers than their parents, but the computer is very seldom used in conjunction with their mathematic lessons [14]. It is important for educators to find new ways in using technology to enhance the teaching methods and thereby to improve learning. The National Council of Teachers of Mathematics [17] states that technology is essential in teaching and learning mathematics mainly because it influences the mathematics that is taught and enhances students' learning.

There are various types of mathematics software that can be found in the market today. Most of the software programmes were developed based upon the needs of the learners. Scientific and graphic calculators, and the variety of software packages such as Maple, Mathematica, Geometers Sketchpad and Autograph are some of the tools available for the teaching and learning of mathematics. This mathematical software has greatly contributed to mathematical research, enabling exciting activities in mathematics and providing extensive data for conjectures. This software program has been developed to access the knowledge of students, and create a plan that when followed will help strengthen the students' weakness. The new technologies can help learners to visualize and understand difficult concepts as well as to help create an active problem solving environment [15]. However, each software packages have its own strength. Its logical to consider students perceived usefulness and ease of use using these mathematic software packages in mathematics teaching and learning as it provides us with some ideas what the real cause might be.

In Malaysia, the cultivation of a mathematically competent and mathematically literate Malaysian workforce anchors on the concomitant improvement of mathematical achievement in Malaysian students in order to possess the mathematical knowledge to produce, use and manipulate new technologies. As the goals of education begin to change to reflect new social and educational needs, teaching strategies also change, and consequently, strategies for integrating technology into teaching and learning.

The use of technology in the use of GSP, Autograph and the graphing calculator has been implemented for the learning of mathematics in Malaysian secondary schools. Considering the investment that the Ministry of Education has made in schools, it is timely to conduct a study on the efficacy of technologies such as the GSP and the graphing calculator on students' achievement, problem solving abilities and on affective attributes such as enjoyment, ease of use, usefulness of these technologies in learning mathematics, However, in order for these technologies to be effective in the learning of mathematics in the classroom, the appropriate role of the technology must be clearly understood.

II. OBJECTIVES

The objectives of this study are to:

1. Compare students' perception of the three mathematical software utilized in mathematics teaching and learning at the Malaysian secondary level among school students based on the following dimensions – perceived ease of use, perceived usefulness and behavioral intention related to use of the technology.

2. Investigate the relationship between attitudes towards mathematical problem solving and students' perception of the technology usage on the following dimensions – perceived ease of use, perceived usefulness and behavioral intention related to use of the technology.

A. Geometer Sketchpad (GSP)

Geometer's Sketchpad (GSP) is a dynamic construction and exploration tools that enables students to explore and understand mathematics in ways that could not be done with traditional ways [7]. This software enables the construction and the animation of an interactive mathematics model to be used and explored by teachers and students [19]. GSP is a powerful drawing program to help students explore and discover topics in geometry to develop a better understanding [11]. By using GSP, students can construct an object and then explore it by dragging the object with the mouse. The software relies on very simple commands that allow the user to effortlessly create, edit, and manipulate accurate geometrical constructions on the computer screen. GSP encourage a process of discovery in which students first visualize and analyze a problem and then make conjectures before attempting a proof. Teachers can use GSP to create worksheet, examination and reports by exporting GSP figures and measurement to spreadsheet, word processor, other drawing programs and the web [7]. Sanders believe that teachers can use GSP in combination with more traditional teaching tools [9].

Numerous studies have been conducted to explore the effectiveness of the use of the Geometer's Sketchpad (GSP) in mathematics learning, especially in the learning of geometry. Yousef's study investigated the effect of using GSP on the high school students and the results indicated that there were significantly different students using GSP and students using traditional tools in the gain of the scores [12]. Lester's research also provides similar results and GSP provides intelligent capabilities for improving teaching and learning mathematics [8]. Growman studied on using the GSP in a geometry Course for Secondary Education Mathematics and the results showed that the use of the GSP has positive reaction from both students and instructors [5].

B. Autograph (Auto)

Autograph is a powerful, interactive and affordable software package spanning topics from pre-Algebra through Calculus. Autograph can be used in the teaching of graphs, transformations, vectors (all in 2D and 3D), and is the perfect tool for understanding the concepts in calculus, trigonometry, polar and parametric plotting and differential equations. Statistics and Probability is also covered, so students can create probability distributions, sample data sets and histograms. Autograph can be used for drawing statistical graphs, functions, and vectors, and for transforming shapes. It also enables users to change and animate graphs, shapes or vectors already plotted to encourage understanding of concepts. The program uses color and animation well and provides excellent help for teachers on using the huge variety of functions. Teachers will need to familiarize themselves thoroughly with the software before using it in the classroom. Many recent studies are on-going to look deeply on the effectiveness of using Autograph in teaching and learning mathematics. This is because Autograph is a self-exploratory tool and has a wonderful interface and capabilities for exploring single variable statistics and probability. Autograph is a new dynamic software for teaching calculus, coordinating geometry, statistics and probability. With a host of dynamic features and 3D options, Autograph is an essential asset covering all teaching needs.

C. Graphing Calculator (GC)

Hand held electronic calculators have been widely used since 1970's while graphing calculators since 1990. Graphing Calculator are approximately the same size of a scientific calculator but a graphics screen replaces that of a numerical display screen. The graphing calculator is not only a teaching tool in the classroom in the hands of the teachers, it is also a teaching tool in the hands of students when given through investigation, concept development and guided discovery exercises, and extended modeling projects [20]. GC also allows students to represent, analyze and explore function. Equation that cannot be solved using algebraic methods can be solved with GC for approximate solutions and sometimes exact solution. GC allows students to graph function quickly, manipulate the graphs and develop generalizations about the functions. A graphing calculator is a learning tool designed to help students visualize and better understand concepts in math and science. GC can be used at all levels of mathematics education including computational skill development [1].

There are many benefits using a handheld device for instruction such as graphic calculator. Dick listed some examples of how GC assists with problem solving. (1) GC frees up time for instruction by reducing attention to algebraic manipulation; (2) GC supplies more tools for problem solving especially students with weaker algebraic skill and (3) GC students are free from numerical and algebraic computations [2]. Meanwhile, meta analysis of findings from [4] shows that using GC, students' operational, computational, conceptual; and problem solving skills were improved. Finding from a research found that students who learned concepts with GC performed better but not significantly better on algebraic skills test than students who learned the concepts without GC [6]. A Meta analysis on 24 studies found students who used GC showed higher achievement than students who did not use GC on problem solving, computation and conceptual understanding [10].

III. TECHNOLOGY ACCEPTANCE MODEL

The Technology acceptance Model (TAM) was developed by Fred Davis and Richard Bagozzi. It is an information theory that models how users come to accept and use a computer based technology. TAM suggested that when users are presented with a new software package, a number of factors influence their decision about how and when they will use it [16],[18]. TAM states that an individual adoption of information technology is dependent on their perceived ease of use and perceived usefulness of the technology. According to the TAM model as described by Davis [13] perceived ease of use of a system has an effect on its perceived usefulness. The behavioral intention to use the system is directly determined by the person's subjective probability that using a specific application will increase his/her job performance (usefulness). Attitude and perceived usefulness are also affected by the degree to which the prospective users expect the system to be free of effort (perceived ease of use) and perceived usefulness impact use of the system.

In this study, TAM is used to identify secondary school student's acceptance towards using GC, GSP and Autograph while learning calculus in class. For that purpose, three of the variables as suggested in Davis [13] were used which is perceived usefulness, perceived ease of use and behavioral intention. In the context of students' perception, perceived usefulness is about the extent to which a student believes that the use of technology (GC, GSP and Autograph) will enhance his or her own understanding in calculus or will enhancing their learning process. Perceived ease of use is about student's belief that using the technology will be free of effort. Meanwhile, behavioral intention refers to student's intention to perform a specific behavior that is using the technology.

IV. METHODOLOGY

An experimental design was used for this study with students selected at random to be assigned to three groups. The experimental group underwent learning using Autograph, GSP and graphing calculator technology. Four phases were conducted: 1) Introduction to Software, 2) Introduction to Quadratic Functions, 3) Integrated teaching and learning using software, 4) testing using the Achievement Test. At the end of the sessions, the students were given questionnaires to measure the efficacy of each software. Students were to give their opinion on the usage and integration of Autograph, Graphing calculator and Geometer Sketchpad based on the selected topic. Three dimensions were investigated namely ease of use on the usage of each of the technological tools, usefulness on the usage of each of the technological tools, and behavioral intention related to the usage of the technologies. The data were analyzed using ANOVA and post-hoc analyses.

A. Results

The results of this study focused on the differences in secondary school learners on perceived ease of use, perceived usefulness and behavioral intention of utilizing or integrating GSP, GC and Autograph in mathematics learning. The students were given the following choices to response to each item:

S = Strongly agree (if you strongly agree to its use)
SA = Somewhat agree (if you somewhat agree in using it)
SD = Somewhat disagree (if you somewhat disagree in using it)
D = Strongly disagree (if you strongly disagree to its use)

Thus the mean response for each item may vary from one to four with high agreement indicating high scores on the perceived ease of use, perceived usefulness and behavioral intention.

V. FINDINGS

A. Perceived Ease Of Use

Seven items were used to measure the perceived ease of use. In this study, perceived ease of use refers to how much effort students perceives using the GC, GSP and Autograph during the learning sessions. The overall mean response to this dimension were as in Table 1 and Figure 1. Findings indicated that on the scale of one to four, students perceived ease of use were high. There were also minimal differences in this dimension in the overall perceived ease of use. The mean scores for the usage of graphic calculator was found higher (mean=3.648) compared to the usage of Autograph (mean=3.546) and GSP software (mean= 3.542). Table 2 displays the mean scores for responses to each item used to measure students perception on ease of use. Items that were strongly agreeable were "learning to use GC is easy for me" (mean= 3.40) and "It is easy for me to remember how to start GC" (mean= 3.26). These students also responded with least agreement on negative items such as "I often become confuse when using GC" (mean= 2.19) and "Interacting using GC often frustrate me" (mean= 1.51). It may be concluded that use of GC was perceived well by the students as compared to use of GSP or Autograph.

Table 1: Comparison of perceived ease of use on using GC/GSP/Autograph

	N	Min	Max	Mean	Standard Deviation
GSP	44	2.29	4.43	3.542	0.443
GC	41	2.29	4.43	3.648	0.476
Auto	39	2.29	4.43	3.546	0.441
Total	124				

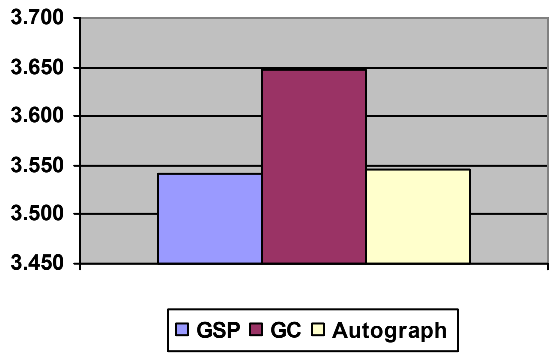

Fig 1 : Mean of perceived ease of use on using GC/GSP/Autograph

Table 2: Mean response to items measuring perceived ease of use on using GC/GSP/Autograph

	Items	GSP	GC	AUTO
1	I often become confuse when using GC/ GSP / Auto.	2.27	2.19	2.26
2	I often make mistakes while using GC/ GSP/ Auto.	2.42	2.24	2.21
3	I need a demonstrator to assist me in using GC/ GSP/ Auto.	2.64	2.65	2.92
4	Learning to use GC/ GSP/ Auto is easy for me.	3.18	3.40	3.31
5	Interacting using GC/ GSP/ Auto often frustrate me.	1.66	1.51	1.59
6	It is easy for me to remember how to start GC/GSP/Auto.	3.16	3.26	3.08
7	As a whole, I find GC/GSP/Auto is easy to use.	3.38	3.43	3.41

Further analysis of the differences on perceived ease of use of the three different types of technological tools, a one way ANOVA wwas used to compare the mean score among the three groups (refer to Table 3). Findings indicated that there is no significant difference in the mean scores on ease of use of the technology between the groups [F(2,121) = 0.626, p = .537].

Table 3 : ANOVA Table

	Sum of Squares	DF	Mean Square	F	Sig
Between Group	14.38	2	7.192	0.626	.537
Inner Group	1390.58	121	11.492		
Total	1404.96	123			

B. Perceived Usefulness

Perceived usefulness measured the degree to which the user believes that using GC, GSP and Autograph will improve students in learning mathematics. For this purpose, eight items were used to measure the perceived usefulness. The overall mean scores for the response of this dimension is as shown in Table 4 and Figure 2. Students rated with higher mean in using GC (mean= 3.512) compared to the usage of Autograph (mean=3.381) and GSP (mean= 3.417). Table 4 displays the mean responses for each item for this dimension. Students who used GC responded very favorably in the measure of perceived usefulness with six items scoring higher mean compared to GSP and Autograph. Items that were strongly agreeable were "using GC can assists me to quickly solve mathematical questions" (mean= 3.67) and "I find using GC is useful in learning mathematics" (mean= 3.67). Students using GC also responded with least agreement on negative items for item "learning mathematics becomes more difficult when using GC"(mean= 1.60).

Table 4: Comparison of perceived usefulness on GC/GSP/Autograph

	N	Min	Max	Mean	Standard Deviation
GSP	44	1.13	4.00	3.417	0.542
GC	41	2.88	4.00	3.512	0.393
Auto	39	1.63	4.00	3.381	0.562
Total	124				

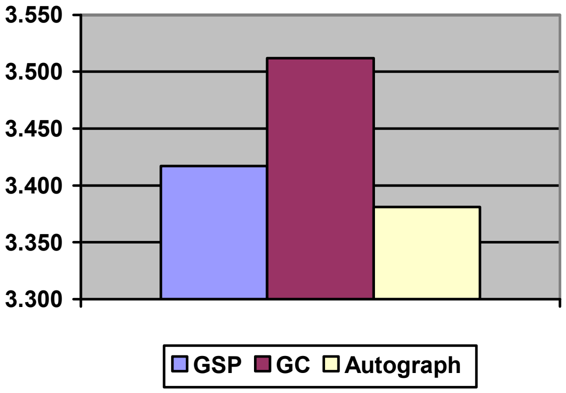

Fig 2 : Mean of perceived usefulness on using GC/GSP/Autograph

Table 5: Mean response to items measuring perceived usefulness on GC/GSP/Autograph

	Items	GSP	GC	AUTO
1	Using GC/GSP/Auto can assist me to understand mathematics better.	3.38	3.38	3.31
2	Using GC/GSP/Auto can assist me to quickly solve mathematical questions.	3.49	3.67	3.54
3	I find using GC/GSP /Auto is useful in learning mathematics.	3.58	3.67	3.46
4	Using GC/GSP/Auto makes it easier to learn mathematics.	3.53	3.57	3.46
5	Learning mathematics becomes more difficult when using GC/GSP/ Auto.	1.73	1.60	1.85
6	I easily remember steps to solve mathematical questions using GC/ GSP/ Auto.	3.00	3.24	3.05
7	Using GC/GSP/Auto saves time to learn mathematics.	3.51	3.50	3.51
8	As a whole, teaching and learning using GC/GSP/ Auto is useful in learning mathematics.	3.62	3.62	3.56

A one way between-groups analysis of variance was conducted to determine the differences in student's perceived usefulness between the three different types of technological tools. Table 6 indicated that there is no significant difference in the mean scores among the groups [$F(2,121) = 0.724$, $p = .487$].

Table 6 : ANOVA Table

	Sum of Squares	DF	Mean Square	F	Sig
Between Group	23.60	2	11.803	0.724	.487
Inner Group	1973.39	121	16.309		
Total	1997.00	123			

C. Behavioral Intention

Altogether there were five items to measure students behavioral intention in using GSP, GC and Autograph. The overall behavioral intention related to use of the software indicated that usage of GC is the highest (mean = 3.419) followed by usage of GSP (mean = 3.404) and Autograph (mean = 3.323). Detailed mean scores for responses of each item are as shown in Table 7. High agreement on item 1 "I intend to use the GC when learning mathematics" (mean = 3.45), item 3 "I intend to use GC to understand mathematics" (mean = 3.45) and item 5 "I intend to recommend GC to my friends to use it when learning mathematics" (mean = 3.45) were obtained.

Table 7: Comparison of perceived Behavior Intention on using technological tools

	N	Min	Max	Mean	Standard Deviation
GSP	45	1.40	4.00	3.404	0.545
GC	41	2.60	4.00	3.419	0.438
Auto	39	1.40	4.00	3.323	0.576
Total	125				

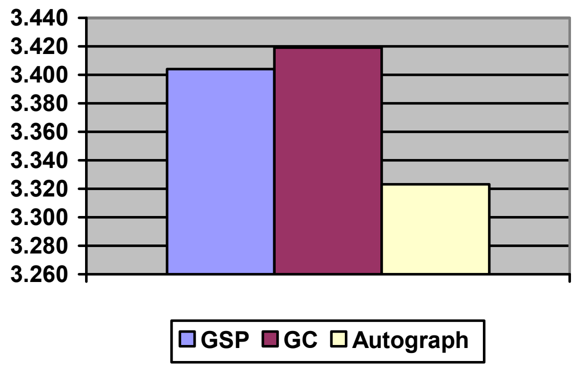

Fig 3 : Mean of behavior Intention on using GC/GSP/Autograph

Table 8: Mean response to items measuring Behavior Intention on using technological tools

	Items	GSP	GC	AUTO
1	I intend to use the GC/ GSP /Auto when learning mathematics	3.44	3.45	3.38
2	I prefer to use GC/GSP /Auto as an additional reference.	3.42	3.33	3.33
3	I intend to use GC/GSP/ Auto to understand mathematics.	3.44	3.45	3.36
4	I prefer to use GC/GSP/ Auto to learn mathematics	3.40	3.41	3.31
5	I intend to recommend GC/GSP/ Auto to my friends to use it when learning mathematics.	3.31	3.45	3.23

A one-way ANOVA indicated that there is no significant difference in mean scores of behavior intention among the groups [$F(2,124) = 0.394$, $p = .675$].

Table 9 : ANOVA test Results

	Sum of Squares	DF	Mean Square	F	Sig
Between Group	5.38	2	2.691	0.394	.675
Inner Group	833.81	122	6.835		
Total	1997.00	124			

VI. CORRELATIONAL ANALYSES

Findings on attitudes toward problem solving were also obtained. Altogether, there were eight items assessing school students' attitudes towards problem solving in mathematics. These scores were then correlated with perceived ease of use, perceived usefulness and behavioral intention of usage for mathematical software in learning. Positive correlations were found between levels of attitudes toward problem solving with perceived ease of use and perceived usefulness towards utilization of technology among the GSP learners. Findings also indicated positive correlations between levels of attitudes toward problem solving with perceived ease of use and behavior intention towards utilization of technology using the GC. However, no significant correlation was obtained between levels of attitudes toward problem solving in mathematics with all three dimension toward utilization of technology in mathematics learning when using Autograph.

Table 10: Correlation matrix of attitudes toward problem solving with perceived ease of use, perceived usefulness and behavior intention of software usage

Factors	GSP	GC	AUTO
Attitudes toward problem solving in mathematics with ease of use	0.477**	0.312*	-0.154
Attitudes toward problem solving in mathematics with usefulness	0.332*	0.287	-0.142
Attitudes toward problem solving in mathematics with behavior intention	0.209	0.364*	-0.123

VII Conclusion

This study aims to explore Malaysian secondary school students' perception to use GC, GSP and Autograph in learning calculus. The result of the study shows that a majority of the students indicated a high positive perception towards the use of GC, GSP and Autograph. Findings revealed that items related to perceived ease of use, usefulness and behavioral intention is favorable towards the use of GC followed by GSP. However, overall mean for all three dimensions were over 3.0.

Further analysis involving statistical test was done. A one way ANOVA was used to compare the mean scores among the three groups (GC, GSP and Autograph) for all three dimensions. Findings indicate that there is no significant difference between the ease of use, usefulness and behavioral intention among the three groups. The results from this study revealed that the use of Graphic Calculator, Geometers' Sketchpad and Autograph conforms to the requirement by students in terms of usefulness, ease of use and behavior intention.

There is variety of mathematical software that can be found in the market today for use in the teaching and learning of mathematics. Teachers are often confused when it comes to choosing the best software for classroom use. It is important for educators to find new ways of using technology to enhance teaching methods and thereby to improve learning. There are various types of mathematics software that can be found in the market today. Most of this software programmes were developed based upon the needs of the learners and also for commercial purposes. However, when selecting the best mathematical software, several factors need to be considered. Besides the effectiveness of the software on student's achievement, factors such as student's perception of the ease of use, usefulness and their behavior intention also need to be examined.

These findings show that students give a highly positive response towards all three technologies used in the study. This shows that GSP, GC and Autograph can be used in teaching and learning mathematics. However, further analysis can be conducted to explore more on student's mathematic development such as the problem solving process, student's procedural and conceptual knowledge and also their mathematics visualizations. In conclusion, Graphing Calculators, Geometers' Sketchpad and Autograph are excellent tools which can foster students to explore and investigate during mathematical activities.

VIII. IMPLICATION

The result of this study could have an implication in the teaching and learning of mathematics in schools. The teaching and learning mathematics in schools should practically advance from the mere traditional method to applications of technology tools or mathematic softwares. Teachers should not only use one software or hand held technology but they need to explore others mathematic softwares in their teaching and learning mathematics. The study would also recommend further studies to be conducted on how to integrate these technologies in mathematics instruction such as the problem solving process, students' procedural and conceptual knowledge and also their mathematics visualizations so that students' mathematical understanding are enhanced and reinforced.

VIX. LIMITATION

Participants of this study were from one secondary schools in Malaysia. For this reason, the generalisability of this study is limited as the conclusion are based on the evidence from this particular study, where the participants were secondary school students in one of the schools in Malaysia.

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