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EXPLORING THE EFFECTS OF TI-84 PLUS ON ACHIEVEMENT AND ANXIETY IN MATHEMATICS

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ABSTRACT. Most of us want our students to feel that mathematics is an enjoyable and rewarding study for them … but do we succeed? Some of our students are successful whereas others are anxious and fearful. The performance of Malaysian students in mathematics has been generally been not good. It has been realized that poor mathematics performance of students at the secondary level would result in a decrease in the number of students getting to the university. It was with this realization that the present project was mooted. This study is designed to investigate the effect of TI-84 Plus graphing calculator on the achievement of mathematics and the students' anxiety. The sample of the study consists of four classes of form four students from two of the public schools in Selangor, Malaysia. In each school, one class was assigned to be the experimental group (N=54) and the other the control group (N=55). For the experimental group, all students used the graphing calculator. The treatment took about ten weeks. Regular teachers taught and used the graphing calculator. A paper and pencil test on the achievement and anxiety test developed by the researcher was given to both groups before and after the treatment. The result showed that there was a significant difference on the achievement and anxiety of the treatment groups ($p < 0.01$).

KEYWORDS. Achievement, Anxiety, Mathematics Anxiety, Graphing Calculator, Technology.

INTRODUCTION

In the era of fast technological advancement, keeping up with the latest innovations and inventions that technology can offer is essential in order to be relevant now and in the future (Abd. Rafie, 2002, Bitter & Hafield, 1994; Pomerantz, 1997; Noraini Idris, 2006). Educators have to be prepared to deal with enormous challenges in mathematics education and to forge ahead because holding on to the old and familiar ways would mean putting students at a disadvantage in a world that is fast embracing technology (Ames, 1992; Dunham & Dick, 1994).

In mathematics, this would mean that the order and treatment of most topics would need to be aligned to new technologies and innovations so that the students can function with optimal advantage with their surroundings. In particular, the place of algebra needs to here-examined such that routine manipulation becomes less important, and topics such as linear algebra and modelling becoming more important. Algebraic proof may be of greater importance since there is more opportunity for more rigorous mathematical argument once a good intuitive understanding is acquired through investigation with the help of technology such as TI-84 graphing calculator.

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Mathematics achievement is an object of much interest and of utmost importance in any secondary school (Noraini Idris, 2002; Dunham & Dick, 1994). It is defined as a measure of the ability of students to understand, analyze and answer specially designed test items based on the standard syllabus. The level of achievement exhibited by the students will categorize them as high or low mathematics achievers. In the present ever-demanding success-oriented society, mathematics achievement is often seen as a key factor in ensuring the success of a student in the school system (Ministry of Education, 2000). In addition, coupled with our country's present emphasis on mathematics subjects as the tickets to becoming a developed nation by the year 2020.

Mathematics teachers also face increasing demands to improve student performances in Mathematics, and this is by no means a simple task in many parts of the country. Many students have the misconception that mathematics, or anything related to mathematics, is confusing and therefore difficult to learn, let alone master (Pomerantz, 1997; Romberg, 1991).

An area of concern in many mathematics classes is the attitude of the students towards mathematics. Specifically, many students find the topic on Straight Lines difficult and boring. Many also find that drawing and interpreting statistical plots and interpreting coordinate geometry is tedious and even confusing (Bitter & Hafield, 1994; Herrera, 2002). This poor attitude towards learning mathematics often leads to the poor appreciation of these two topics, which will consequently result in poor mathematics achievement. This poor attitude could be attributed to a number of reasons, namely the students a) were not able visualize what they were learning, b) found that plotting and drawing graphs was tedious and time consuming, c) realized that plotting graphs was a routine procedure and thus became boring, or realize that problem solving situations, activities and the answers that were generated were too unit These factors will tend to make learning mathematics unpopular and uninteresting.

The National Philosophy of Education and Malaysia's Vision 2020 aims to produce a new generation of Malaysians who are able to think critically and systematically and who are able to use their knowledge of mathematics to meet the new challenges in this fast changing world (Ministry of Education, 2000). In the age of Information and Communication Technology (ICT), the use of current technology is essential to enhance the teaching and learning process in order to stimulate the critical and logical thinking capabilities of the students. The use of graphing calculators will cause changes in the way teachers teach and in the way students learn mathematics. It will also reduce the drudgery of applying arithmetic and algebraic procedures when those procedures are not the focus of the lesson. They provide better ways to compute and manipulate symbols. Graphing calculators can help students to generate hypothetical examples that emulate everyday situations so that the students can experience real-life problems and situations (Dunham & Dick, 1994; Noraini Idris, 2006). By generating theoretical data, students can be led to apply higher order thinking skills in various problem-solving situations. Logical thinking can be taught. practiced and nurtured by projecting "what if' questions. Students can then be made to rationalize the decisions that they have made.

Often in schools where students adopt ability goals, students come to believe that success is defined in terms of how they do in comparison to others. Mistakes and failures, because they indicate lack of ability, are threats to a students' self-confidence. Students who adopt ability goals are more likely to avoid challenging tasks and to give up in the face of difficulty. In contrast, learning goals define success in terms of developing skills, self-confidence, expanding knowledge, and gain understanding (Maehr & Mify, 1997). Success means being able to do something you could not do before. When students adopt learning goals, they take on more challenging tasks, persist longer, are less debilitated by mistakes and failure, and use higher-level thinking skills than when they focus on ability goals (Ames, 1992; Elliot & Dweck, 1988).

In technology-supported learning environments as envisaged in the Malaysian Smart School conceptualization, students are encouraged to be reflective (Malaysian Ministry of Education, 1997). Fast technological advancement poses great challenges to mathematics educators in Malaysia. Changes for improvement and development have to be undertaken to be prepared in dealing with such enormous challenges. There is a need to be familiar with these technological trends so as to be relevant in the present and future. In secondary school mathematics, this means that the order and treatment of most topics would need to change

STATEMENT OF THE PROBLEM

The teaching and learning of mathematics in many Malaysian schools has been reported to be too teacher centered and that students are not given enough opportunities to develop their own thinking skills (Malaysian Ministry of Education, 2000). This situation invariably results in students becoming passive receivers of information, which in many cases do not result in conceptual understanding. Many students are not able to comprehend what their mathematics teachers teach because mathematics content is taught with the intention of finishing the syllabus and preparing for examinations. Little regard is given to how well the students understand mathematical concepts. Research has also shown that students in many of today's mathematics classrooms have little opportunity to explore mathematical patterns and processes (Ross & Kurtz, 1993) which can help them understand mathematical concepts better.

In addition, teacher-centered classes are usually carried out without the help of teaching aids or tools. Moreover, most existing teaching aids are inanimate objects that cannot respond and complement the varying levels of student understanding found in a classroom. These teaching or learning aids hardly allow opportunities for students to be creative and imaginative in their thinking and reasoning. Such tools do not allow students to consider "what if" situations, which are very useful and effective for building conceptual understanding. It is by considering alternative mathematical situations that better mathematical understanding can be developed.

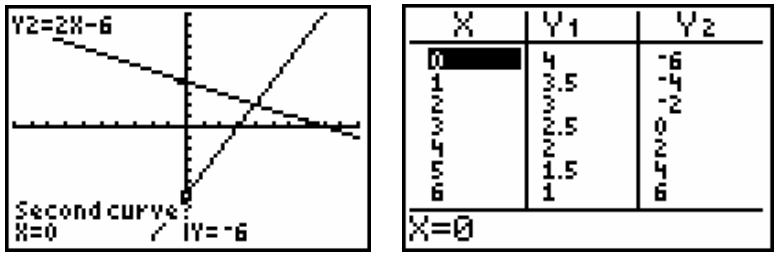
Poor reasoning skills are also another area of concern among secondary school students. Many are unable to extract necessary information from given data, and many more are unable to

interpret answers and make conclusions. However it is unfair to blame the students for their lack of thinking and reasoning skills. Much of the problem may lie with the pedagogical approach. Teacher-centered classrooms seldom encourage or involve students in mathematical communication and in making logical reasoning. Traditional teaching approaches emphasizes more on how much the students can remember and less on how well the students can think and reason. Thus learning becomes forced and seldom brings satisfaction to the students.

Thus learning mathematics for many weaker students becomes uninteresting and boring. This poor attitude towards learning mathematics is not helpful for the students, as it will lead to poor mathematics performances (Dunham & Dick, 1994). The reasons for the students' poor attitude towards mathematics may also lie with traditional teaching approaches, like the "chalk-and-talk" method where the teacher talks and the students only listen. Instead teaching and learning mathematics should portray an active and dynamic classroom with the students thinking, learning and applying what they have learnt. Mathematics should be enjoyable and time to learn. In fact, in his paper "Directions and Policy: Mathematics Education and National Development", the Malaysian Director-General of Education also encouraged mathematics teachers to steer the perceptions and interests of students towards the concept of "Mathematics is Fun" (Abd. Rafie Mahat, 2002). Thus by building good attitudes towards learning mathematics, it is hoped that mathematics performance can also improve.

In addition, Mathematics is traditionally thought of as the memorization of formulae, the long and monotonous computation and the manipulation of numbers. It is also tradition that rules that the tools to computing and manipulating mathematics are the pencil and paper. Finally it is also thought that the conventional way of delivering lessons is the chalk and talk method. However, mathematics has always been concerned with logic and reasoning, number sense, problem solving, and a search for relationships, and abstract thinking (Pomerantz. 1997). Therefore, educationists are earnestly looking beyond the traditional approaches to enhance the teaching and learning process. The use of TI-84 Plus graphing calculators is one of the avenues that can inject new excitement and enthusiasm into the mathematics teaching and leaming process. One of the important criteria is that mathematics encourages logical thinking among students. Graphing calculator has the ability to draw and analyze graphs, carry out complex computations, numerically solve equations, perform matrix arithmetic, statistical analysis and plotting a graph as in Figure 1.

Figure 1. Plotting a Graph



Conceptual Framework

The performance of Malaysian students in mathematics has been generally been not good. It has been realized that poor mathematics performance of students at the secondary level would result in a decrease in the number of students getting to the university. It was with this realization that the present project was mooted. Three constructs are thus compared leading to the purpose of the study: achievement, anxiety of mathematics, and use of graphing calculators.

Achievement assists the learning and teaching of mathematics: The confidence that children bring to mathematics reflects the confidence of those around them: peers, home, school, community the media. To help students develop self confidence to mathematics and towards themselves as learners and users of mathematics, they should experience enjoyment through confidence in their ability to succeed, a sense of purpose through relevant experience and meaningful activities, pride in achievement and pleasure in the use of suitable materials and graphic calculator. Confidence is an important factor 111 success in any area and this is especially so in mathematics. Students need to experience success frequently in order to feel confident that they are making progress and to enhance their enjoyment of mathematics.

Further, the amount of effort students are willing to invest in a mathematical task is dependent not only on the value they recognize in the task but also on their perception of the likelihood that they will successfully complete the task (Maehr & Midgley, 1991, Noraini Idris, 2006). Problem solving, discovering relationships, proving theorems, analyzing situations, and interpreting mathematical communications are all cognitive tasks requiring students to work through perplexing moments. Those who are not confident in their mathematical abilities tend to stop working on a task as soon as they become perplexed; more-confident students tolerate perplexity longer and are more likely to continue with the task.

Many experienced teachers recognize that anxiety is another domain that affects students' achievement in mathematics. Most students feel anxious and tense when manipulating numbers and solving mathematical problems. Mathematics anxiety is a psychological state engendered when a student experiences or expects to lose self-esteem in confronting a mathematical situation. Such anxiety prevents a student from learning even the simplest mathematical task.

Graphing calculators can be used to enable students to investigate and apply mathematical ideas in a way not easily achieved by other means. The TI-84 Plus graphics calculator is relatively new technology in Malaysia that was developed as aid in teaching and learning mathematics. In Malaysia, as the graphing calculator is still being introduced, there were not many schools which have explored the use of the technology. The motivation to learn and perform better in mathematics is affected by the learning procedure, the instructional materials and technology used, and non-cognitive factor such as anxiety.

PURPOSE OF THE STUDY

The purpose of this research was to explore and investigate the use of TI-84 Plus graphing calculator as a tool in enhancing teaching and how its help in achievement and reduce anxiety in mathematics.

Specifically, the research project seeks to:

(1) determine the effects of graphics calculator use on students achievement in mathematics;

(2) determine if there is any significant change in the respondents' anxiety in mathematics; and

(3) gather students' insights about the graphing calculator as an instructional technology.

Specifically, it will seek to find answers to the following questions:

(1) Does the graphing calculator contribute in increasing student achievement in mathematics?

(2) Does the graphing calculator contribute in reducing students' anxiety in mathematics?

(3) What are the perceptions of students towards the use of the graphic calculator?

METHODOLOGY

Location and Sample: The research study employed the quasi-experimental, non-equivalent control pretest and posttest design. The sample of the study consisted of two experimental secondary schools in Selangor, Malaysia. Each school was assigned one intact Form Four class to be the experimental group and another one intact class to be the control group. The experimental group learned mathematics using the TI-84 Plus graphing calculators for ten weeks, while the control group teamed mathematics using the traditional whole-class instruction. The mathematics teachers who taught in the experimental group were trained in the workshops. During the workshops, the teachers were trained using TI-84 Plus graphing calculator to teach and also designed the instructional activities to be used in the treatment group.

Instruments: The instruments in this research consisted of (1) Mathematics achievement test, (2) Mathematics Anxiety test, and (3) Questionnaire for students' perception. The three instruments were designed by the researcher. The instruments were pilot-tested in another school of similar characteristics to the selected study school. The degree of internal consistency as estimated by Cronbach alpha for mathematics achievement was .81 and mathematics anxiety was .78

Procedure: Quantitative data was collected using a pretest and posttest, mathematics anxiety, and questionnaire for students' perception.

Data Analysis: Data from students' achievement in pretest and posttest, mathematics anxiety and questionnaire for students' perception were analyzed using quantitative analysis. The SPSS program was used to analyze the data.

RESULTS OF THE STUDY

Student Achievement in Mathematics: To answer the question whether students in the experimental group using TI-84 Plus graphing calculator achieved significantly greater improvement on mathematics achievement compared to students in the control group who did not use the graphing calculator, the adjusted mean scores on the posttest of the two groups were determined. Table 1 provides a summary of the adjusted means of the experimental and control groups of subjects.

Table 1. Means and Standard Deviations for Experimental and Control Groups on Pre- and Posttest Mathematics

Test		**Experimental**	**Control**
Covariate (Pretest)	N	54	55
	Mean	12. 203	12.211
	Standard Deviation	3.679	3.216
Dependent (Posttest)	N	54	55
	Mean	34.714	29.271
	Standard Deviation	3.213	3.145
	Adjusted Means	34.823	29.315

The pretest mean for the experimental group was 12.203 (SD=3.679) compared to the control group means of 12.211 (SD=3 .216). The posttest means for both groups increased from the pretest, with experimental group showing the greater increase. Table I shows that the adjusted mean of the experimental group was significantly higher than the adjusted mean of the control group. The results showed that students in the experimental group showed significantly greater improvement on mathematics achievement than students in the control group.

Mathematics Anxiety Scores: To answer the question whether students in the experimental group using TI-84 Plus graphing calculator reduced significantly on mathematics anxiety compared to students in the control group who did not use the graphing calculator, the adjusted mean scores on the posttest of the two groups were determined. Table 2 provides a summary of the adjusted means of the experimental and control groups of subjects.

Table 2. Means and Standard Deviations for Experimental and Control Groups on Pre- and Posttest Mathematics

Test		**Experimental**	**Control**
Covariate (Pretest)	N	54	55
	Mean	3.11	3.03
	Standard Deviation	1.67	1.21
Dependent (Posttest)	N	54	55
	Mean	1.34	2.92
	Standard Deviation	1.21	1.23
	Adjusted Means	1.15	2.31

The pretest mean for the experimental group was 3.11 (SD=1.67) compared to the control group means of 3.03 (SD=1 .21). The posttest means for both groups reduced from the pretest, with experimental group showing the greater reduction. Table 2 shows that the adjusted mean of the experimental group was significantly reduced than the adjusted mean of the control group. The results showed that students in the experimental group showed significantly greater reduction on mathematics anxiety than students in the control group.

Perceptions of Students Towards the Use of Graphing Calculator: Fifty three Form Four students completed a form with the questions as shown in Table 3. The scaled score is calculated based on five point scale from 5 (strongly agree) to 1 (strongly disagree).

As shown in Table 3, most of the students showed positive reactions towards the use of TI – 84 Plus graphing calculator.

Table 3. Students' Survey Result on the Usage of Graphing Calculator

Item	5	4	3	2	1
1. It was easy to learn math using TI-83.	5	48	1	0	0
2. I enjoy math better now than before.	10	42	1	1	0
3. I like math better now.	12	39	2	1	0
4. I learn math better with TI-83 instead of only with book.	11	42	1	1	0
5. I spent more time on math now than before.	9	43	1	1	0
6. I feel confident about trying a new problem on the TI-83	12	41	1	0	0
7. Graphic calculator TI-ES help me in understanding the topics better.	11	42	1	0	0
8. I am able to interact with my teacher and friends.	8	44	0	2	0
9. It helps me to learn mathematics by discovering.	10	42	1	1	0

As shown in Table 3, most of the students showed positive reactions towards the ue of graphing calculators. Students felt that graphing calculator made them comfortable learning mathematics.

DISCUSSION AND CONCLUSION

In this study, the TI-84 Plus graphing calculator was used as a tool in the teaching and learning of two topics, namely straight-line geometry and Statistics, in the mathematics classroom. The results of the study as discussed shows promising implications for the potential of the graphing calculator in teaching mathematics at the secondary school level.

From the results obtained, a number of implications can be put forward in the interest of improving mathematics teaching in the classroom. Firstly, the generally significant differences

of mathematics achievement of the experimental groups as compared to the control groups indicate that the graphing calculator can possibly contribute towards improved learning in mathematics. The results of this study is consistent with the TIMSS' findings that students with the highest scores used calculators more frequently in mathematics instruction than students with the lowest scores (Mullis et al., 2000). This observation can therefore encourage classroom teachers and even curriculum developers on the potential of the graphing calculator as an effective tool in learning mathematics.

Secondly, the significantly reduced scores in the Test of Mathematics Anxiety achieved by the students in the experimental groups implied that learning Statistics and Straight Line Geometry with the graphing calculator had been beneficial for the students. The students seem to have indirectly acquired the skills of logical thinking whilst manipulating and processing data on the graphing calculator. Thus these results imply that the graphing calculator not only helps students to process data and perform calculations, it may also help them to develop and cultivate better thinking skills. NCTM (1989, 1991, 2000) claim that students will not loose their ability to think if they were to use the graphing calculator. Instead, the students need to know more than what keys to push and in what order. They need to understand the mathematics of the problem they are going to solve. They need to be able to decide what information to enter and what operations to use, and then they need to interpret the results that the calculator gives them in return. Therefore the calculator makes them think even more.

Such logical thinking skills would therefore become a valuable asset for the students in not only learning mathematics but also in managing their other studies and their own lives, Indeed, this would be exactly what the mathematics educators strives to inculcate in the young minds of the nation. Therefore, the result of this study has strong implications for the graphing calculator to become an integral and important learning tool in the school curriculum. In fact thousands of teachers in the US can attest to the power of this using graphing technology in the mathematics classroom (Herrera, 2002). According to Bert Waits, the co-founder of an organization called Teachers Teaching with Technology, the graphing calculator is an excellent pedagogical tool as it provides multi- representational approaches to the teaching and learning of mathematics. This is because it allows a problem to be viewed and manipulated analytically using the MATH functions, viewed and interpreted graphically using the graphing functions, and viewed numerically using the table functions (Herrera, 2002).

Similarly, the students in the experimental group showed a reduced in mathematics anxiety test indicate that the usage of the graphing calculator seemed to have helped the experimental group students to be better able to extract information and patterns from given data or diagrams. This ability can be useful for students attempting problem solving questions and activities. In problem-solving situations, the students need to correctly extract information or patterns from given diagrams, graphs or tables to be able to correctly answer or solve the

problems. Thus this study suggests that the graphing calculator can play an important role in helping the students acquire the ability to disembed information and pattern from given data or diagrams.

From the results of the Attitudes Inventory, it was clearly seen that most students enjoyed their Mathematics lessons when they could make use of the graphing calculator. Many of the students indicated that they had enjoyed being able to explore mathematical concepts using the Tl-84 Plus graphing calculators and were amazed of its capabilities and of its wide range of functionalities. Many of the students even claimed that they would like to learn mathematics using the graphing calculator. These results support the findings of a calculator project to evaluate the impact of calculators in mathematics instruction carried out in the US, which claims that calculators can motivate and support students who have negative attitudes towards mathematics (Bitter and Hatfield, 1994). These results also support Noraini's (2002) study among Malaysian Form Four students, which reported that using the graphing calculator had helped the study sample to reduce their mathematics anxiety. This study therefore suggests that the graphing calculator may represent an effective tool to encourage students to enjoy learning mathematics.

In conclusion, this study suggests that the use of graphing calculators in the mathematics classroom is especially effective in helping students to perform better in mathematics, think more logically and critically. There is also evidence that students who use graphing calculators during their mathematics lessons are better able to disembed information from given data or patterns. Consequently, these calculators may also encourage students to learn mathematics in a more enjoyable, yet effective way.

Learning does not occur in a vacuum. The brain constantly searches for patterns and attempts to categorize information into relevant chunks of information. It matches, compares, and patterns incoming information after information already stored in memory. This is done at both the conscious and subconscious levels. The more meaningful, relevant, and complex the sensory inputs is, the more actively the brain will attempt to integrate and develop patterns. Usage of graphing calculator in the learning of mathematics provides the complex and relevant stimuli necessary to allow learning to occur more easily. By using graphing calculator, exploring possibilities, and seeing the outcomes of their investigations, students can form the connections between previous learning and new information.

Students generally have very positive attitudes towards graphic calculator and their use. Graphics calculators give students a powerful means of solving problems. Students enjoy using graphics calculators. Many graphic calculators provide students with an environment in which mistakes can be quickly and easily amended, trial solutions are encouraged, mistakes often lead to unexpected results that encourage further exploration.

Mathematical ideas, situations and problems can be explored and investigated in many possible ways. Some investigations can be carried out by using graphics calculator. One aspect of an investigation is the formulation of problems and another is the solving of those problems. Part of the value of using the investigational approach to problem solving is that the students construct their own questions. This means they will be more motivated to solve the problems raised because they are of more immediate concern and interest.

If students have confidence in their ability to understand, develop, use and discuss mathematics, they are more likely to apply the mathematics they have been learning to problems they encounter in everyday life. This will lead to even greater confidence in their ability to solve mathematical problems and thereby enhance self-esteem. The processes which are successful used in solving problems will lead to further learning because they contribute to the ability to reason and think mathematically.

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