Using Graphic Calculators in Teaching and Learning Functions and Graphs Topic

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ABSTRACT The objective of this study is to investigate foundation students' performance and their perceptions toward the adoption of the TI-84 Plus Graphic Calculator as a tool in improving their understanding in learning Functions and Graphs topic. The sample selected is students from University College of Technology Sarawak (UCTS). Two groups of foundation in science students involved in this study. One group which consists of 40 students served as experimental group and was taught the functions and graphs topic with the graphic calculators and another group consists of 38 students was taught with traditional method without graphic calculator and served as control group. Before the study started, a pre-test was given to both groups. At the end of the study, post-test with same items as pre-test was given to the students and experimental group is allowed to use graphic calculator. The statistical results indicated a significant difference in the mean scores for both groups. Specifically, the results suggested that students were able to perform well significantly in the test with graphic calculator. A questionnaire was distributed to the experimental groups and collected data were then analyzed by using SPSS 23.0. From the analysis results, experimental group students showed favorable response towards the use of graphic calculators as a tool in learning mathematics since it helps them to gain better understanding about the functions and graphs topic compared to traditional approach.

KEYWORDS: Graphic calculator; Functions and graphs; Student's result; Student's attitude; Technology graphical tool

I Received 7 January 2019 **II Revised** 30 January 2019 **II Accepted** 12 February 2019 **II Online** 15 February 2019 **II © Transactions on Science and Technology I**

INTRODUCTION

The use of graphic calculator in Malaysia is still in the beginning level compared to other developed countries such as Australia. Although the integration of graphic calculator in the teaching and learning of mathematics was introduced to secondary school starting 2004, but the implementation is still at the minimum level (Hasan et al., 2005). Use of technology tools in teaching and learning process increase students' ability in learn, experience, communicate and do mathematics (National Council of Teachers of Mathematics, 2015). One of the technology tools that can be used is graphic calculator. Graphic calculators can motivate students to explore and investigate mathematics problems (Ali et al., 2002). Horton et al. (2004) studied the use of graphic calculator in algebra lesson and they found out that students in experimental group showed a statistically significant improvement in attitudes. Therefore, they suggested that technology graphical-based tutorials beneficial in improving student's attitudes in learning mathematics (Horton et al., 2004; Parrot & Leong, 2018).

Parrot & Leong (2014) studied that students who underwent the intervention approach, i.e. with access to graphic calculator had better perception on the problem solving task compared to those underwent the traditional approach. Students had more time to think on the problem itself without worrying about long algebraic solution procedures. Berry et al. (2005) investigated that the problem solving strategies of students is improved as they used a graphics calculator and the key record device has proved to be an excellent tool for collecting data (Idris & Chew, 2011). Tajudin et al. (2007) concluded that there are pedagogical impacts of the use of graphics calculator as a technology tool in learning of mathematics in Malaysia. The research's result showed that the use of graphic calculators improved students' achievement in learning Straight Lines topic. Students did not find it complicated or difficult to use.

Kastberg & Leatham (2005) summarized the implication of using graphic calculators in teaching and learning for teacher in secondary level into three main aspects: accessibility to graphic calculators, the position of graphic calculator in mathematics curriculum, and the connection between graphic calculators and pedagogical practice. Teacher's belief and knowledge about graphic calculators impact student access to graphic calculator and at the same time, it will influence students' mathematical performance. It was found that graphic calculator as exploratory and graphing tool enabled students to visualize the concept better and they can make generalizations about the mathematical properties (Ng, 2011). Ali & Kor (2004) discussed the appropriate use of graphing technology tools can enhance student's understanding in a student-centred learning environment and students will have good attitude towards this innovative learning mode.

The objective of this research is to investigate foundation students' performance and their perceptions toward the adoption of the TI-84 Plus Graphic Calculator as a tool in enhancing their understanding in learning Functions and Graphs topic.

METHODOLOGY

This research involved convenient sampling approach and two groups of foundation in science students from University College of Technology Sarawak, UCTS involved in this study. One group which consists of 40 students served as experimental group and was taught the functions and graphs topic with the graphic calculators for four one-hour tutorial lessons within two weeks' time and another group consists of 38 students was taught with traditional method without graphic calculator and served as control group. Before the study started, a pre-test was given to both groups. The questions for the pre- and post-test is adapted from the "Calculus: Graphing Relationship" activity spreadsheet in Texas Instrument's (2018) website and the test was designed so that the control group can answer the questions as well without graphic calculator. The test was designed for students to explore information about features of a graph based on the first derivative. The instrument used is attached at the Appendix. At the end of the study, post-test with same items as pre-test was given to the students and experimental group is allowed to use graphic calculator. The graphic calculators were provided by Statworks [M] Sdn. Bhd. in loan basis to the experimental group. A questionnaire was distributed to the experimental group students and collected data was then analyzed by using SPSS 23.0. Questionnaire used is adapted from Tan et al. (2013) and main aims in measuring student's perceptions toward the quality output from calculator and also their attitude towards learning differentiation by using graphing calculator.

RESULT AND DISCUSSION

Table 1 and **Table 2** show the background of the students in control group and also experimental group. The control group had 38 students, 17 male and 21 female. The experimental group had 40 students, 17 male and 23 female. Both groups had comparable ethnic backgrounds and ability in learning mathematics.

Table 1. Frequency distribution of gender of the subjects

Group			Frequency	Percent	Valid Percent	Cumulative Percent
Control group	Valid	Male	17	44.7	44.7	44.7
		Female	21	55.3	55.3	100.0
		Total	38	100.0	100.0	
Experimental group	Valid	Male	17	42.5	42.5	42.5
		Female	23	57.5	57.5	100.0
		Total	40	100.0	100.0	

Table 2. Frequency distribution of the subject ethnicity

Group			Frequency	Percent	Valid Percent	Cumulative Percent
Control group	Valid	Malay	6	15.8	15.8	15.8
		Chinese	23	60.5	60.5	76.3
		Others	9	23.7	23.7	100.0
		Total	38	100.0	100.0	
Experimental group	Valid	Malay	2	5.0	5.0	5.0
		Chinese	25	62.5	62.5	67.5
		Others	12	30.0	30.0	97.5
		Missing	1	2.5	2.5	100.0
		Total	40	100.0	100.0	

Pre- and Post-Test Result Analysis

Shapiro-Wilk's test is a common test for normality and from **Table 3**'s result indicates that the student's scores in pre-test and post-test were normally distributed ($p > 0.05$). **Table 4** shows the mean scores and standard deviation for pre-test obtained by both control group and experimental group. The *p*-value was 0.680 indicates that there is no significant difference in the mean score for both groups. This result shows that both groups have similar abilities before graphing calculators is introduced to the experimental group in their mathematics lessons.

Table 3. Test of Normality for Pre-test and Post test Score

Group		Shapiro-Wilk		
		Statistic	df	Sig.
Pre-test	Control Group	.967	38	.322
	Experimental Group	.983	40	.796
Post-test	Control Group	.960	38	.184
	Experimental Group	.930	40	.061

Table 4. Independent t-Test for Pre-Test

Group		N	Mean	Std. Deviation	Std. Error Mean	Sig. (2-tailed)
Pre-test	Control Group	38	6.1974	1.93663	.31416	.680
	Experimental Group	40	6.3850	2.07149	.32753	

An independent t-test was used to determine whether there was a statistically significant difference in post-test's mean score between the control group and experimental group. **Table 5** shows the mean test scores for post-test between the control group and experimental group. The experimental group score (M=10.7625, SD=3.23639) was higher than the control group score (M=7.1711, SD=1.99612). The significant (2-tailed) value is 0.000 and it shows that the difference in post-test's mean score for both groups is significant. Specifically, the results suggested that students in experimental group were able to perform well significantly in the test.

Table 5. Independent t-Test for Post-Test

Group		N	Mean	Std. Deviation	Std. Error Mean	Sig. (2-tailed)
Post-test	Control Group	38	7.1711	1.98398	.32184	.000
	Experimental Group	40	10.7625	3.23639	.51172	

A paired-samples t-test was conducted to compare the mean score of pre-test and post-test for individual student. There was a significant difference in the scores for pre-test (M=6.2936, SD=1.99612) and post-test (M=9.0128, SD=3.23433). The significant (2-tailed) value in **Table 6** is 0.000. The result in **Table 6** showed that the mean score for post-test was greater than the mean for pre-test.

Table 6. Result of Paired t-Test for Pre-Test and Post-Test

		Mean	N	Std. Deviation	Std. Error Mean	Sig. (2-tailed)
Pair 1	Pre-test	6.2936	78	1.99612	.22602	.000
	Post-test	9.0128	78	3.23433	.36622	

Questionnaire's Analysis

The data from questionnaire was analyzed with descriptive statistics by using frequency in percentages form. Data collected from questionnaire are to measure the four aspects: 'Opinion on graphing calculator usage', 'Understanding of Functions and Graphs Concepts', 'Preference in learning mathematics' and 'Student's attitude towards learning Functions and Graphs' (Tan et al., 2013).

Table 7. Percentages of student's opinion on graphing calculator usage

Questions	Strongly Disagree	Disagree	Slightly Disagree	Undecided	Slightly Agree	Agree	Strongly agree
I am able to read and interpret all points on the graph clearly with graphic calculator.	0.0%	1.5%	4.6%	7.7%	26.2%	46.2%	13.8%
Graphic calculator is easier to visualize the concept of functions and its derivative graphs.	0.0%	0.0%	6.2%	6.2%	33.8%	32.3%	21.5%
The graphic calculator display accurate answers.	0.0%	1.5%	1.5%	3.1%	18.5%	44.6%	30.8%
The graphic calculator illustrate graph clearly.	0.0%	0.0%	4.6%	6.2%	27.7%	30.8%	29.2%
Graphic calculator is a user friendly tool.	1.5%	1.5%	9.2%	13.8%	36.9%	26.2%	10.8%
The graphic calculator is easy to use.	6.2%	1.5%	27.7%	10.8%	21.5%	26.2%	6.2%
I spend less time to solve graphing problem by using graphic calculator.	0.0%	3.1%	3.1%	16.9%	33.8%	29.2%	13.8%

Table 7 shows the proportions of students towards their opinion on the usage of graphic calculator based on a Likert's scale. The students are clearly in favour of the visual feature of the graphic calculator. Notable percentage are observed in those who agree and strongly agree that they were able to read and interpret all points on the graph, able to visualize the concept of functions and its derivative graphs and that, the graphic calculator is able to display accurate answers. The percentages are 60%, 53.8% and 75.4% respectively. No one denied that the graphic calculator able to illustrate graph clearly. A minority of the students (37%) agreed and strongly agreed that graphic calculator is a user friendly tool. 26.2% of them agreed and 6.2% only strongly agreed that the graphic calculator is easy to use. About 43% agreed and strongly agreed that they spent less time to solve graphing problem using graphic calculator.

Table 8. Percentages of student's opinion on how the graphing calculator helps in understanding Functions and Graphs topic

Questions	Strongly Disagree	Disagree	Slightly Disagree	Undecided	Slightly Agree	Agree	Strongly agree
The graphic calculator helps me to understand better the concepts of functions and graphs.	0.0%	3.1%	3.1%	23.1%	33.8%	24.6%	12.3%
The graphic calculator helps me to understand the relationship between function and its graph clearly.	1.5%	1.5%	3.1%	23.1%	27.7%	35.4%	7.7%
I get to learn the topic in greater depth.	1.5%	1.5%	6.2%	21.5%	35.4%	20.0%	13.8%
I understand the topic better when using the graphic calculator compared to the traditional approach.	0.0%	1.5%	7.7%	16.9%	29.2%	33.8%	10.8%

From **Table 8**, majority of the students favour in using graphic calculator since it helps them to gain better understanding about the concepts and relationship of functions and by using graphic calculator. They agreed that by using graphic calculator they learn mathematics in greater depth. 44.6% of the students supported the idea that they understand the topic better when using the graphic calculator compared to traditional approach.

Table 9. Percentages of student's opinion on their preference in learning mathematics

Questions	Strongly Disagree	Disagree	Slightly Disagree	Undecided	Slightly Agree	Agree	Strongly agree
I am more confident at solving graphing problems in graphing topic.	0.0%	1.5%	7.7%	16.9%	29.2%	33.8%	10.8%
I dare to explore the behavior of functions and its derivative graphs by using graphic calculator.	0.0%	1.5%	0.0%	20.0%	26.2%	30.8%	21.5%
It is good if graphic calculator can be used in the examination.	3.1%	1.5%	3.1%	7.7%	21.5%	29.2%	33.8%
It is good if graphic calculator is a calculation tool in our Mathematics course.	0.0%	0.0%	1.5%	10.8%	21.5%	36.9%	29.2%
By using graphic calculator, I am more willing to try solving graphing problem that require long and complicated calculation.	3.1%	0.0%	3.1%	12.3%	29.2%	24.6%	27.7%

Table 9 presents the percentage of students' preference in learning mathematics by using graphic calculator. The students are clearly agreed and strongly agreed that they were more confident at solving graphing problems in graphing topic and dared to explore the behaviour of functions and its derivative graphs by using graphic calculator. They are more willing to try solving graphing problem that require longer and complicated calculation by using the device. 63% of the students agreed and strongly agreed that it would be good if this calculator can be used in the examination and if it is a calculation tool in the Mathematics course.

Table 10. Percentages of student's attitude in learning mathematics after they have been explored the graphing calculator

Questions	Strongly Disagree	Disagree	Slightly Disagree	Undecided	Slightly Agree	Agree	Strongly agree
Graphic calculator helps me in my discussion with peers in the lecture/tutorial.	0.0	0.0	3.1	27.7	13.8	43.1	12.3
Graphic calculator helps me interact with lecturer in the lecture/tutorial.	0.0	0.0	1.5	15.4	35.4	29.2	18.5
Learning Mathematics in graphing part with graphic calculator is more fun.	0.0	0.0	4.6	7.7	21.5	47.7	18.5
Learning Mathematics in graphing part with graphic calculator is easier.	3.1	0.0	1.5	13.8	32.3	30.8	18.5
I enjoy learning Mathematics with graphic calculator.	1.5	1.5	6.2	10.8	24.6	38.5	16.9

Data from **Table 10** shows that 55.4% of the students agreed and strongly agreed that the graphing calculator helped them in their discussion with peers and 47.7% of them can interact better with the lecturer during lecture or tutorial hours. 66.2%, 49.3% and 55.4% of the students agreed and strongly agreed that learning Mathematics in graphing part with graphic calculator is more fun, easier and they enjoyed themselves while learning mathematics with the graphic calculator.

LIMITATION OF THE STUDY

During the study, researcher discovered some problems especially time constraint. From the questionnaire's analysis, it was noticed that only a minority of students (37%) agreed and strongly agreed that graphic calculator is a user friendly tool due to they experienced difficulty in using the graphic calculator. The study was conducted in two-week times only and therefore students had not enough time practice and explore the function of the graphic calculator.

The graphic calculators were provided by Statworks [M] Sdn. Bhd. in loan basis for 2 weeks' time only. Students only explored the functions of this calculator during the lessons but there was no continuous practice after that.

CONCLUSION

Based on the statistical results, there is a significant difference in the scores for control group and experimental group. It is found that students have better achievement if using graphic calculator during the test. From the questionnaire results, students showed favorable response towards the use of graphic calculators as a tool in learning mathematics and they felt that it would be good if this calculator is a calculation tool in their Mathematics course and can be used in the examination. The graphic calculator is a useful tool since it can display accurate answers and illustrate graphs clearly. It gave room for them to dare to explore the behavior of functions and its derivative graphs by using graphic calculator. It also helped the students to communicate better and involve in the problem solving process with lecturers and friends. The fun and enjoyable learning mathematics moments made the learning process easy.

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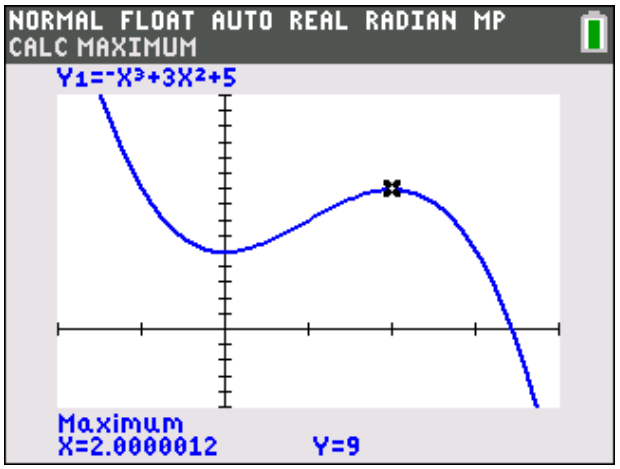
APPENDIX

Pre- & Post-Test [Total Score:15 Marks]

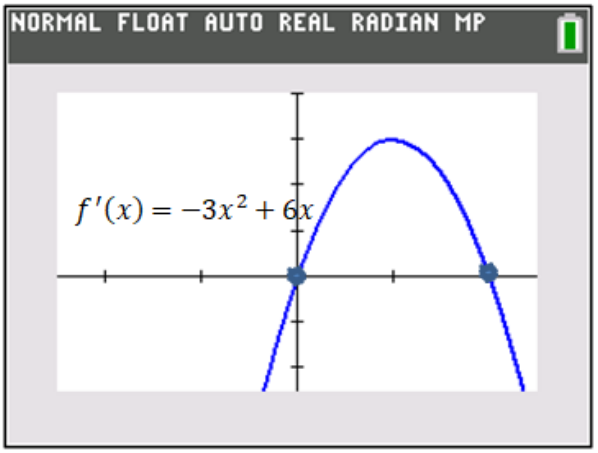
1. Graph $f(x) = -x^3 + 3x^2 + 5$ with $-2 \le x \le 4$. [4 marks]



2. Determine the intervals of x where the function increases / decreases. [2 marks]
The function increases over $[0,2]$ *and decreases over* $(-\infty,0]$ *and* $[2,\infty)$.

3. Explain with reasons the nature of the values of its derivative have over an interval when the function increases. [2 marks]
The derivative should have positive values. *[1]*
The derivative is the rate of change or slope at a point, and increasing graph has a positive rate of change. *[1]*

4. Figure 1 is the derivative graph of $f(x)$. Circle the point/s that has same x-coordinate with turning point/s of $f(x)$. [1 mark]



5. Explain the condition of the cubic graph when the derivative crosses the x-axis from positive to negative and vice versa. [2 marks]

When derivative crosses the x-axis from positive to negative, the function has a local maximum. [1]

When derivative crosses the x-axis from negative to positive, the function has a local minimum. [1]

6. Summarize three main concepts that you explored in this assignment. [4 marks]

-The derivative is positive when the graph of the function is increasing and the derivative is negative when the function is decreasing. [1]

- The graph of the function is concave upward when the derivative crosses the x-axis from negative to positive and the graph of the function is concave downward when the first derivative crosses the x-axis from negative to positive. [2]

- The derivative is equal to zero when local maximum or minimum point occurs. [1]

ISSN 2289-8786. http://tost.unise.org/