STUDENTS' SKILLS IN MATHEMATICAL COMPUTATION USING GRAPHING CALCULATOR

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Abstract: *This study sought to find out the students' skills in mathematical computation using graphing calculator in teaching Mathematics among freshmen College Algebra students of the College of Education of Jose Rizal Memorial State University, Philippines. The skills that the students possessed in both the control and the experimental groups on the topics included in this experiment is equivalent or comparable before the intervention. The study also concludes that the experimental group performs significantly skillful than the control group after the intervention. It can be deduced further that there is a significant variation in the students' skills in mathematical computation between the control group with the traditional method of teaching and the experimental group with the used of graphing calculator in teaching and learning Mathematics. In addition, the study concludes that both the interventions, traditional method of teaching and using graphing calculator in teaching and learning Mathematics, make improvement in the students' skills in mathematical computation. This means that students perform skillfully better during the posttest than during the pretest. However, students' skills in mathematical computation in the experimental group are greatly influenced by the graphing calculator used by teachers and students in College Algebra class. This concludes that students in the experimental group perform skillfully better than their counterpart.*

1. Introduction

Today's Mathematics classrooms are facing rapid change more than any other educational discipline. These changes are centered not only what is being taught, but also on how it is being taught. Educationally, [5] averred that the world is in a technological boom which Mathematics classrooms have been flooded with electronic teaching tools. There have been transitions in Mathematics classrooms, such as the evolution from blackboard to whiteboard to smartboard, but ultimately those changes do not drastically alter the way in which information is presented. Some classrooms have abandoned the use of textbooks to provide students with the chance to discover more on their own and use each other as learning resources. Despite the importance of these changes, [4] stressed that the most important change in the past few decades has been the arrival of graphing calculators. The user-friendliness and portability of these devices have had a major effect on the access that students now have to new ways of thinking. In [2], it is pointed out that teachers and students now have a new sense of power in the classroom because of the visual nature of these graphing calculators.

In the Philippines, one of the challenges confronting a Mathematics teacher in integrating technology like graphing calculators in Mathematics teaching is the unavailability and lack of the gadget for use in the classroom [1]. The graphing calculator has a powerful algebraic function. The use of a variety of its built in programs can carry out different kinds of calculations and transformations of polynomials, matrices, determinants, factorizations, equation solving, the seeking of limits and trigonometric functions, and many others. Such functions have not only provided strong support for the teaching of Mathematics, especially beginning calculus and other higher Mathematics content at the secondary school level, but also graphing calculators have become good tools for independent exploration and experiments [8].

Imbued with the quest of providing research – based decisions involving graphing calculators and students' performance in Mathematics among Education students of Jose Rizal Memorial State University, Dipolog Campus, Dipolog City, the researchers are encouraged to conduct this study to find out the students' skills in mathematical computation using calculators and determine their relationship to students' performance in Mathematics. The result of this study is expected to construct possible corrective measures in enhancing students' skills in mathematical computation using calculators and performance among the teachers and students.

2. Theoretical and Conceptual Framework of the Study

This study is anchored on Dreyfus' "Theory of Skill Acquisition" as cited in [7]. The theory states that as human beings acquire a skill through instruction and experiences, they do not appear to leap suddenly from rule-guided "knowing that" to experience-based "knowing-how". This emphasizes that many skills could not simply be reduced to "knowing that". The reason that many are not conscious of their "knowing how" is possibly because they take their knowing-how for granted. It is believed that there is a gradual process involved for a learner to go through in order for him to reach the stage of expertise or knowing-how. The theory illustrates the five clear stages that a learner goes through in order to evolve from knowing-that, novice, to knowing-how, expert.

The first stage is called novice. A novice has some general ideas and is in the process of learning the rules, such as knowing the functions and the uses of the keys of the calculator. The second stage is advanced beginner stage. In this stage, the learner's performance improves to a relatively acceptable level only after the novice has had enough experience in copying the real situation. During the third stage, competence, the learner starts becoming personally involved with the task. He starts to see more than one option from which he has to choose the best one. In the fourth stage or proficiency stage, the learner, while intuitively understanding his task, still thinks analytically about his actions. The last stage is called expertise. Experts in general know what to do based on mature understanding of the task. An expert has had so much experience with the task that the skill of doing the task is a part of him. He acts upon correct intuitions without analytically thinking about his every method. These stages emphasize on the fact that practice is required for the learner to maintain the knowing-how. Without practice, the learner will gradually lose his expertise and is most likely to regress as far back as the competence stage.

This study is also grounded on the "Theory of Performance" [3] which states that "performance develops and relates concepts to form a framework that can be used to explain results as well as improvements". According to him, to perform is to produce valued results. He said further that developing performance is a journey, and level of performance describes location in the journey. This theory exactly connects the present investigation since the present study embraces the determination of students' Mathematics performance. Likewise, finding the level of Mathematics performance among students in College Algebra purports to performance improvements in the subject.

It is for this reason that this study was conducted to establish support and strengthen research outputs involving the use of graphing calculators in Mathematics classroom. The research aimed to investigate the students' skills in mathematical computation using graphing calculator in relation to students' Mathematics performance in College Algebra among students in the College of Education of Jose Rizal Memorial State University, Dipolog Campus in the City of Dipolog.

In this investigation, the researcher focused and considered two teaching approaches such as graphing calculator utilization and the traditional model in teaching Mathematics as independent variables. It is asserted in [6] that graphing calculator technology is a hand-held mathematics computer that draws and analyses graphs, computes the values of mathematical expression, solves equations, performs symbolic manipulation, performs statistical analyses, makes program and communicates information between devices. Simply stated, it is considerably more versatile as a teaching or learning tool in which a graphics screen replaces that of a numerical display screen. This feature, coupled with built-in software, is capable of undertaking all kinds of mathematical work. Some of the tasks made possible are graphing functions, tabulating functions, analyzing statistical data, manipulating matrices, equation-solving, calculus, probability and complex analysis.

In this investigation, the researchers attempted to find out the students' skills in mathematical computation using graphing calculator which included skill in solving zeros of function, skill in writing equations of functions, skill in solving problems involving functions, skill in solving inequalities, and skill in graphing functions.

The graphing calculator can easily be used to solve and/or check algebraic equations. For example, one solves for x given $4x + 1 = 9$. To process the correct value of x, the following steps are to be used, namely: enter the left side of the equation into Y_1, enter the right side of the equation into Y_2, graph (one may need to adjust the window to see where the two graphs intersect), and find the point of intersection to reveal the answer by pressing 2nd CALC above TRACE, #5 Intersect.

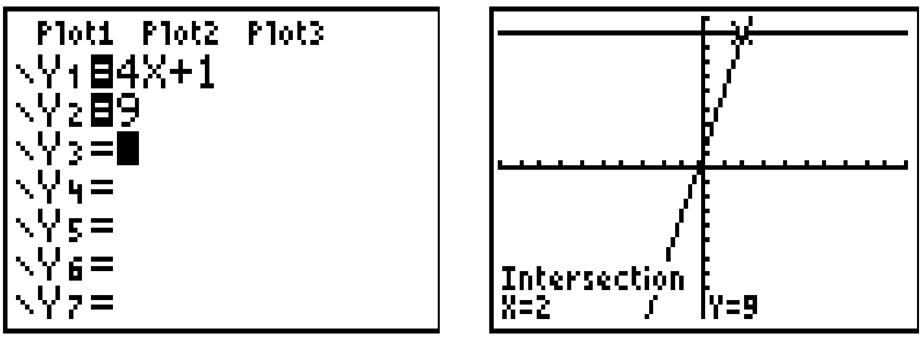
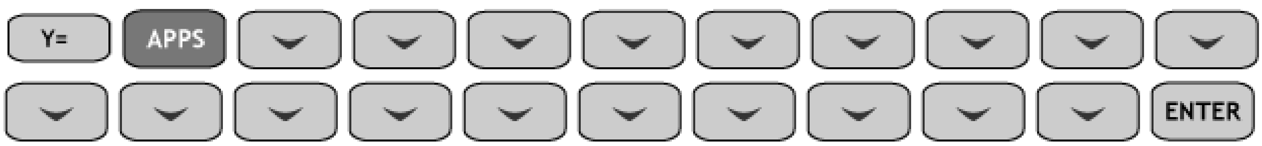
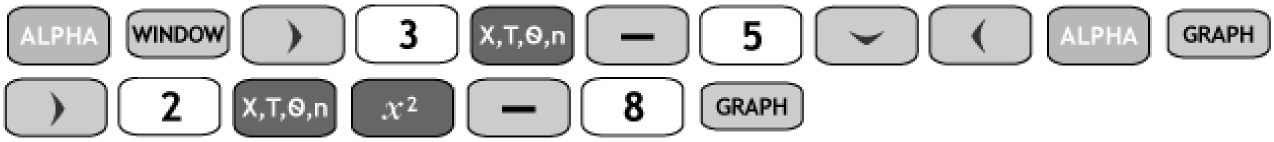


Figure 2.1 The Screen Windows of the Plot and the Graph of the Equation

Another example is finding the solution of the system of inequalities $y < 3x-5$ and $y \geq 2x^2 - 8$. Using the TI 84 plus, the commands are as follows:





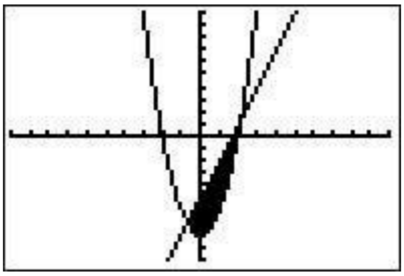


Figure 2.2 The Screen Window of the Graph & Solution of the System of Inequalities

The points on the shaded area satisfy both $y < 3x-5$ and $y \geq 2x^2 - 8$ and is considered the solution.

OR you can use the following commands:

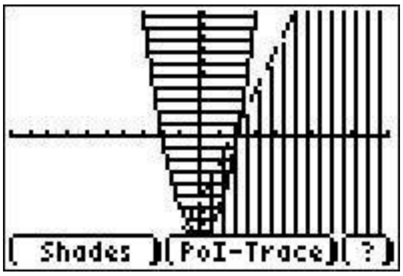


Figure 2.3 The Screen Window of the Graph & Solution of the System of Inequalities

The points on the double shaded area or the intersection of the two graphs satisfy both $y < 3x-5$ and $y \geq 2x^2 - 8$ and is considered the solution.

Another important variable in the study is the traditional method of teaching Mathematics. In this model, purely the talk, chalk, board and eraser method of teaching Mathematics are employed. This conventional strategy does not employ technological gadgets since it is using chalk and talk scheme. Moreover, this technique does not allow students to see a clear and pedagogically sound connection between input parameters and output results of mathematical concepts.

There were two groups of respondents in the experiment, namely: the control and experimental groups. The two groups were exposed to the same lessons/subject matters in College Algebra, to wit: Linear Functions, Quadratic Functions, and Polynomial Functions. The experimental group was exposed to each of the topics mentioned and developed in the students the five skills, namely: solving zeros of a function, writing equations of functions, solving problems involving functions, solving inequalities, and graphing functions. Functions in this study were limited to linear, quadratic and polynomial functions.

Likewise, the study measured the students' Mathematics performance in two ways, the pretest and the posttest. The pretest was administered using the validated teacher–made test to the respondents in both the control and the experimental groups before the experiment commenced, after which the experiment followed. The posttest, on the other hand, was given using the same teacher – made test as administered in the pretest to the respondents in both the control and experimental groups after the experiment ended.

3. Results and Discussions

Problem No. 1. What is the pretest skill performance in mathematical computation of the students in the control and experimental groups?

The data which are presented in Tables 3.1 and 3.2 are results of the pretest administered to the control and experimental groups. The pretest skill performance was obtained before the groups were exposed to the assigned interventions.

Table 3.1 Pretest Skill Performance in Mathematical Computation of the Students in the Control Group

Students' Skills	**No. of Items**	μ	$\overline{X}$	σ	z	**Description**
Solving Zeros of a Function	12	9	2.64	1.566	27.85	Less Skillful
Writing Equations of Functions	12	9	2.40	1.469	30.78	Not Skillful
Solving Problems Involving Functions	12	9	2.49	1.545	28.89	Less Skillful
Solving Inequalities	12	9	2.13	1.610	29.26	Not Skillful
Graphing of Functions	12	9	1.87	1.454	33.61	Not Skillful
Total	**60**	**45**	**11.53**	**7.171**	**32.00**	**Not Skillful**

μ = hypothetical mean, σ = standard deviation, $\overline{X}$ = actual mean, z = computed z – value

Table 3.1 presents the pretest skill performance in mathematical computation of the students in the control group. Five skills were measured in the experiment, namely: skill in solving zeros of function, skill in writing equations of functions, skill in solving problems involving functions, skill in solving inequalities, and skill in graphing of functions. Sixty (60) items were used to determine the five skills broken into 12 items per skill. The expected performance of the students was set at

75 percent of the items that determined each skill. In this case, score of 9 was set as the expected performance per skill and score of 45 for the whole instrument.

As reflected in Table 3.1, the students of the control group are "less skillful" in solving zeros of a function and solving problems involving functions. Moreover, the respondents in the control group are not "skillfull" in writing equations of functions, solving inequalities and graphing functions. Overall and on average, the control group is "not skillful" to the different skills presented in the table.

Table 3.2 Pretest Skill Performance in Mathematical Computation of the Students in the Experimental Group

Students' Skills	**No. of Items**	μ	$\overline{X}$	σ	z	**Description**
Solving Zeros of a Function	12	9	2.27	1.125	41.44	Not Skillful
Writing Equations of Functions	12	9	2.31	1.151	40.25	Not Skillful
Solving Problems Involving Functions	12	9	2.19	1.197	39.43	Not Skillful
Solving Inequalities	12	9	2.06	1.192	40.32	Not Skillful
Graphing of Functions	12	9	1.96	1.202	40.59	Not Skillful
Total	**60**	**45**	**10.79**	**5.604**	**42.29**	**Not Skillful**

μ = hypothetical mean, σ = standard deviation, $\overline{X}$ = actual mean, z = computed z – value

As shown in Table 3.2, the students in the experimental group are "not skillful" in all of the five skills, from solving zeros of functions to graphing of functions.

Problem No. 2. Is there a significant difference on the pretest skill performance in mathematical computation between the control and experimental groups?

Table 3.3 Test of Difference on the Pretest Skill Performance in Mathematical Computation Between the Control and Experimental Groups

Group	**N**	**Mean**	**Mean Difference**	**Standard Deviation**	**Computed t**	**Critical t**	**Decision**
Control	47	11.53	-0.74	7.171	0.561	1.661	Not Significant
Experim	48	10.79		5.604			

Reflected in table 4 is the t-test analysis of the pretest results of the skill performance in mathematical computation between the control and experimental groups. Base on the computed t value and the critical t value at α=0.05, it is found out that there is no significant difference between the pretest skill performance of the control and experimental groups.

Problem No. 3. What is the posttest skill performance in mathematical computation of the students in the control and experimental groups?

Table 3.4 Posttest Skill Performance in Mathematical Computation of the Students in the Control Group

Students' Skills	No. of Items	μ	$\overline{X}$	σ	z	Description
Solving Zeros of a Function	12	9	5.511	1.679	14.25	Skillful
Writing Equations of Functions	12	9	5.426	1.612	15.20	Skillful
Solving Problems Involving Functions	12	9	5.447	1.572	15.50	Skillful
Solving Inequalities	12	9	5.383	1.609	15.41	Skillful
Graphing of Functions	12	9	5.319	1.682	14.74	Skillful
Total	**60**	**45**	**27.09**	**7.865**	**15.62**	**Skillful**

μ = hypothetical mean, σ = standard deviation, $\overline{X}$ = actual mean, z = computed z – value

Manifested in Table 3.4 is the performance of the control group in the post test skill in mathematical computations. As seen in the table, students in the control group are "skillful" in all of the five skills from solving zeros of a function to graphing of functions.

Table 3.5 Posttest Skill Performance in Mathematical Computation of the Students in the Experimental Group

Students' Skills	No. of Items	μ	$\overline{X}$	σ	z	Description
Solving Zeros of a Function	12	9	10.29	0.683	13.10	Very Much Skillful
Writing Equations of Functions	12	9	10.10	0.778	9.83	Very Much Skillful
Solving Problems Involving Functions	12	9	9.88	0.841	7.21	Very Much Skillful
Solving Inequalities	12	9	9.94	0.909	7.15	Very Much Skillful
Graphing of Functions	12	9	9.81	0.842	6.69	Very Much Skillful
Total	**60**	**45**	**50.02**	**2.178**	**15.97**	**Very Much Skillful**

μ = hypothetical mean, σ = standard deviation, $\overline{X}$ = actual mean, z = computed z – value

Revealed in Table 3.5 is the post test skill performance in mathematical computation in the experimental group. As reflected, the experimental group is “very much skilful” in all of the five skills from solving zeros of a function to graphing functions.

Problem No. 4. Is there a significant difference on the posttest skill performance in mathematical computation between the control and experimental groups?

Table 3.6 Test of Difference on the Posttest Skill Performance in Mathematical Computation Between the Control and Experimental Groups

Group	N	Mean	Mean Difference	Standard Deviation	Computed t	Critical t	Interpretation
Control	47	27.09		7.865			Significant
Experim	48	50.02	22.93	2.178	19.458	1.661	

Table 3.6 shows the t-test analysis on the post test skill performance in mathematical computation between the control and experimental groups. Based on the computed t-value and the critical t-value at $\alpha=0.05$, there is a significant difference on the post skill performance between the experimental and control groups.

Problem No. 5. Is there a significant difference between the pretest and posttest skill performance in mathematical computation of the control group?

Table 3.7 Test of Difference Between the Pretest and Posttest Skill Performance in Mathematical Computation of the Control Group

Control Group	N	Mean	Mean Difference	Standard Deviation	Computed t	Critical t	Interpretation
Pretest	47	11.53		7.171			
Posttest	47	27.09	-15.56	7.865	12.694	1.679	Significant

Viewed in Table 3.7 is the t-test analysis between pretest and post test skill performance of the control group. Based on the computed t-value and critical t-value at $\alpha=0.05$, there is a significant difference between pretest and post test skill performance of the control group.

Problem No. 6. Is there a significant difference between the pretest and posttest skill performance in mathematical computation of the experimental group?

Table 3.8 Test of Difference Between the Pretest and Posttest Skill Performance in Mathematical Computation of the Experimental Group

Experi Group	N	Mean	Mean Difference	Standard Deviation	Computed t	Critical t	Interpretation
Pretest	48	10.79		5.604			
Posttest	48	50.02	39.23	2.178	51.510	1.678	Significant

Disclosed in Table 3.8 is the t-test analysis between pretest and post test skill performance of the experimental group. Based on the computed t-value and critical t-value at $\alpha=0.05$, there is a significant difference between pretest and post test skill performance of the experimental group.

Problem No. 7. Is there a significant difference in the pretest and posttest mean gain on skill performance in mathematical computation between the control and experimental groups?

Table 3.9 Test of Difference on the Pretest and Posttest Mean Gain on Skill Performance in Mathematical Computation Between the Control and Experimental Groups

Group	N	Mean Gain	Mean Difference	Standard Deviation	Computed t	Critical t	Interpretation
Control	47	15.56		8.400			
Experim	48	39.23	23.67	5.276	16.488*	1.661	Significant

Table 3.9 discloses the t-test analysis of the pretest and post test mean gain on skill performance in mathematical computation between the control and experimental groups. Based on the computed t-value and critical t-value at $\alpha=0.05$, there is a significant difference of the pretest and post test mean gain on skill performance between the control and experimental groups.

4. Findings

Base on the analysis and interpretation of the data collected in this study, the following findings were revealed: (1) The pretest skill performance in mathematical computation of the control and the experimental groups was described as “not skillful”. Pretest performance of the control group was 11.53 while in the experimental group was 10.79 in which both were far behind the 75 percent of the total items tested; (2) There was no significant difference in the pretest skill performance in mathematical computation between the control and experimental groups; (3) The posttest skill performance in mathematical computation of the control group which was 27.09 was described as “skillful” while the posttest skill performance in mathematical computation of the experimental group which was 50.02 was described as “very much skillful”; (4) There was a significant difference in the posttest skill performance in mathematical computation between the control and experimental groups; (5) There was a significant difference between the pretest and posttest skill performance in mathematical computation of the control group; (6) There was a significant difference between the pretest and posttest skill performance in mathematical computation of students in the experimental group; and (7) There was a significant difference in the mean gain obtained on students’ skills in mathematical computation between the control and experimental groups.

5. Conclusions

Based on the findings, the skills that the students possessed in both the control and the experimental groups on the topics included in this experiment is equivalent or comparable before the intervention. The study also concludes that the experimental group performs significantly skillful than the control group after the intervention. It can be deduced further that there is a significant variation in the students’ skills in mathematical computation between the control group with the traditional method of teaching and the experimental group with the used of calculator in teaching and learning Mathematics. In addition, the study concludes that both the interventions, traditional method of teaching and using calculator in teaching and learning Mathematics, make improvement in the students' skills in mathematical computation. This means that students perform skillfully better during the posttest than during the pretest. However, students' skills in mathematical computation in the experimental group are greatly influenced by the calculator used by teachers and students in College Algebra class. This concludes that students in the experimental group perform skillfully better than their counterpart.

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