Educational Administration: Theory and Practice
2024, 30(6), 3446-3455
ISSN: 2148-2403
https://kuey.net/

Research Article

Improving Performance and Level of Attitude Towards Learning Integral Calculus Using GeoGebra

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Citation: Manalaysay, Ellenita G, et al (2024), Improving Performance and Level of Attitude Towards Learning Integral Calculus Using GeoGebra, *Educational Administration: Theory and Practice*, 30(6), 3446-3455, Doi: 10.53555/kuey.v30i6.415

ARTICLE INFO

ABSTRACT

Teaching calculus has always been challenging for mathematics teachers as most students dread the subject and negatively approach it. Teachers and school administrators must find ways to improve students' mathematical achievement. This action research utilized a quasi-experimental design to determine the effect of using GeoGebra on the student's performance and attitude toward integral calculus. Pre-tests and post-tests were administered to the experimental and control groups to measure performance and attitude towards mathematics. The two groups were taught the same lesson: the geometric solution of plane areas in integral calculus. The control group was taught using the conventional approach, while the experimental group was taught using GeoGebra. Results showed no difference between the pre-test and ATMI scores of the two groups before the experiment. Both the control group and the experimental group gained improvement in their performance after the experiment. It was further revealed a significant difference between their pre-test and post-test scores in favor of the experimental group who were taught with GeoGebra integration. A comparison of their ATMI scores before and after the experiment showed no significant difference for the control group. At the same time, the scores of the experimental group were observed to be significantly different. Further analyses showed that students who were exposed to GeoGebra enhanced their confidence in their performance in mathematics, found more enjoyment in dealing with mathematics, and increased their desire to study mathematics but were not affected in terms of their perception of the importance and relevance of mathematics in their lives.

Keywords: *GeoGebra, mathematics performance , attitude towards mathematics, teaching and learning, pedagogy*

INTRODUCTION

Most students dread mathematics and show negative attitude towards it. Despite the usefulness and great significance of mathematics in learning other disciplines such as science and technology, people especially students have the anxiety toward it. This makes the teaching of mathematics a great challenge to the members of any academic institution. Administrators need to design and create programs that will affect improvement on students' mathematical achievement. Government of many countries are struggling in considering how to provide best mathematics education for their students the reason why their educators have to address the importance in new mode of curriculum, pedagogy and learning assessments (H. W. Ker, 2013).

The students' positive attitude towards mathematics connects to better learning of the subject as concluded by the researchers in Stanford University School of Medicine (E. Digitale, 2018). Both the student's desire to learn a certain subject and the teacher's competency affect learning. The study of Andaya (2014) revealed that mathematics achievements are highly correlated to individual and instructional factors and moderately correlated to classroom management and evaluation factors.

Introduction of new, various and innovative teaching strategies at different circumstances should be integrated in the teaching of mathematics to attain effectiveness. It is suggested in the study of Sule and Yusuf (2018) that students must be exposed to various teaching aids and techniques fitted and effective to different classroom situations and lessons to improve learning.

Olicia (2019) conducted an action research that investigated the effectiveness of Differentiated Instruction in teaching English in her classes resulting to the improved students' achievement in learning the subject. It was

concluded in the study that the DI is an effective strategy to teach the subject and it was recommended that teachers of the subject should be encouraged, be trained and be prepared for use of this strategy to motivate students and learn the subject effectively.

Another study validated the advantage of the use of different strategies in teaching statistics to affect students' achievement and attitude toward the subject. According to the study of Ragasa (2008) , the combination of computer-assisted and collaborative work improves learning without significant effect on attitude of students who were subjected to the integration of computer -assisted and collaborative work during the teaching of statistics. Dick and Hollebrand (2022) showed how the use of technology as a tool in teaching mathematics assists students develop understanding of mathematics and enhance classroom lessons. According to the article written by G. Picha (2018) researches show that incorporating technology through specific apps that focus on math lessons with the use of computer simulations and programs elevates mathematics learning. The millennial students are born in the world of technology. Teachers in the future must learn to integrate technology in their classes to give experiences to students in mathematics in the modern world (Powers, R. & Blubaugh, W., 2016).

The study of Sia-Acejo (2011) on the use of Technology – Based Heuristic Learning (TBHL) as an approach in teaching analytic Geometry revealed that there is significant difference between the post test results of the students exposed to TBHL and conventional learning It was validated that TBHL is effective when it was observed that students who underwent TBHL gained higher achievement that the students exposed to the conventional learning.

With the mounting use of internet, teachers and future teachers must learn how to incorporate computer applications in math classes to support instruction. Microworlds and simulations can provide experiences and means to make mathematics and science concepts appealing and easier to comprehend, according to the book of James M. Cooper (2006). In the book entitled " Teaching with Technologies - The Essential Guide" by Sarah Younie and Marilyn Leask (2013), they stressed out that teachers must learn to adapt technological advances applicable to classroom purposes. They cited studies that showed the potential benefits from the use of technology in classroom instructions. One study cited was the use of interactive white board that lead to enhanced students motivation and improved academic achievement.

Calculus can be a challenging subject to learn since it requires the integration of several other areas of mathematics during the learning process, including algebra, trigonometry, analytic geometry, and solid mensuration. Students who are confident in their understanding of the concepts will have less trouble grasping calculus concepts. The success of the teaching and learning process depends on having knowledge of these subjects and knowing when and how they are employed in the study of calculus. The instructors should study, design, plan, and innovate an instructional strategy that will boost student achievement and facilitate effective learning. The researchers carried out this investigation for this purpose.

The purpose of the study was to ascertain the impact of GeoGebra-based calculus instruction on students' mathematical performance and attitude. The usage of GeoGebra may make it easier for learners to graph equations, which is a crucial skill for acquiring geometric solutions through calculus.

METHODOLOGY

A quasi – experimental research design was used in this study to determine the effects of the use of GeoGebra in teaching Integral Calculus to the performance and attitude towards it of freshmen Engineering students of a State university situated in the Philippines on a two (2) - week lesson.

Focus group discussions were conducted among freshmen students who have taken Integral Calculus in the previous semester, First Semester of Academic Year 2018-2019. The FGD aimed to gather baseline data such as student's passing rate in the subject, students' challenges in learning the subject and their suggestions on how teaching and learning could be improved in the subject.

The researchers then intended to devise an alternative way of utilizing GeoGebra in teaching integral calculus. GeoGebra is a free interactive mobile application that may be downloaded. It is an interactive tool that can solve the area and volume of geometric forms as well as graph equations. However, the application's use in this study is restricted to graphing alone. GeoGebra was used to build a lesson plan for teaching geometric solutions applying integral calculus. The lesson plan includes a review of analytical geometry, a lecture on plane areas on intersecting curves, a student worksheet on plane areas, a sample solution to a plane area problem, and discussions on the worksheet problems' solutions.

Two groups of freshmen engineering students enrolled in COE 104 (Calculus 2) were identified as the samples of the study. The control group consisting of 131 students were taught of the lessons and worksheet problems using the conventional method while the experimental group composed of 131 students was taught of the same lessons and exposed to the same worksheet problems with teaching method tooled by GeoGebra. These students were instructed to download the applications in their mobile phone prior before the start of the teaching experiment.

A teacher - made achievement test validated by teachers with expertise in the subject served as the pre-test and the post-test given to the respondents. It was composed of 15 multiple choice items about geometric solutions on plane areas. The Attitude Toward Mathematics Inventory (ATMI) developed and validated by Tapia and Marsh II (1996) was administered to both groups before and after the experiment. It is a 40-item survey and

a 4 – factor survey with reliability coefficient of 0.97 designed to measure high school and college students' attitude toward mathematics. The ATMI was designed to investigate the four (4) underlying factors of students' attitude towards mathematics. The four factors considered in this inventory are the students' confidence, value, enjoyment and motivation. The confidence factor measures the students' confidence and self- concept of their performance toward mathematics. The factor of valuing mathematics intends to measure the students' perception of the importance, relevance and worth of mathematics to their life at present and in the future. Items included in the inventory under the enjoyment factor measure how much the students enjoy studying and working with mathematics while the motivation factor are items that measure the students' interest of studying mathematics and their desire to do further studies in mathematics.

The results of the pre-test and the post tests were compared to determine whether the integration of GeoGebra in teaching integral calculus is effective or not. Results of the mathematics attitude survey scores from both groups were analyzed to determine the effect of the use of the mobile apps to the students' attitude toward mathematics.

Another FGD was conducted among the students who experienced teaching with GeoGebra integration. The FGD aimed to identify the advantages and disadvantages of technology integration in class. This activity also helped the researchers to validate quantitative data obtained from the achievement test and ATMI scores.

RESULTS AND DISCUSSION

Students' Suggestions to Overcome the Challenges in Integral Calculus

The results of the initial FGD with the students who have taken Integral Calculus in the previous semester conducted by the researchers has been transcribed and summarized as shown in Table 1.

Table 1. Students' Suggestions to Overcome the Challenges in Integral Calculus

Make the class/lessons interesting.
Have a motivating teacher.
Give various examples exposing them in all level of difficulty (easy, average, difficult)
Use technology or innovation that interests their generation.
Teacher should be sensitive to the different level of capability of his students.

Table 1 shows that the students believed they can overcome the challenges in the subject if there is a motivating teacher who is sensitive to the capability of his students. It was also suggested that lessons should be made interesting, with various and different kinds of examples appropriate to the competence of the students and must involve the application of innovations and technology that catches students' interests. The results show that teacher and pedagogical factors should be given attention to improve the students' performance and enhance student's attitude towards the subject.

Table 2. Comparison Between the Pre Test Scores of the Control Group and the Experimental Group

Group Statistics

Grouping Variable		N	Mean	Std. Deviation	Std. Error Mean
Pre-Test Scores	Control	131	4.2977	1.82586	.15953
	Exp	131	4.5191	2.13163	.18624

The table above compared the performance of the two groups in integral calculus before they were taught of the same lessons. It was shown that the mean score of the pre-test of the control group before they were taught using the traditional method is 4.2977 with a standard deviation of 1.82586 while the mean score of the pre-test of the experimental group before they were taught with the integration of GeoGebra is 4.5191 with a standard deviation of 2.13163.

Table 3. Levene's test of equality of Variance – Independent Sample Test

		. Levene's test of equality of Variance		t- test for equality of means		
		F	Sig	t	df	Sig (2-tailed)
Pretest Scores	Equal variances assumed	3.051	.082	-.903	260	.367
	Equal variances not assumed			-.903	254.006	.368

The independent samples test in Table 3 showed that there exists no significant difference between the two groups with a p-value (Sig – 2 tailed) of 0.368. It means that for the specific data sets there exists 36.8% chance that most of the time there will be no difference. This is a very good reference point for the experiment since the results indicated that there is no different level of intelligence in the two groups included in the study.

Table 4. Comparison Between the Attitude Towards Mathematics Inventory (ATMI) Scores of the Control Group and the Experimental Group Before the Experiment

Group Statistics					
Grouping Variable		N	Mean	Std. Deviation	Std. Error Mean
Attitude Before	Control	131	139.1603	18.36377	1.60445
	Experimental	131	141.1298	20.01822	1.74900

As shown in Table 4, the ATMI scores of the control group before the conduct of the intervention is 139.1603 with a standard deviation of 18.36377 while that of the experimental group has a mean score of 141.1298 with a standard deviation of 20.01822.

Table 5. Levene's Test of Equality of Variance – ATMI Scores Before the Teaching Experiment

		Levene's test of equality of Variance		t- test for equality of means		
		F	Sig	t	df	Sig (2-tailed)
ATMI Scores Before	Equal variances assumed	.896	.345	-.830	260	.407
	Equal variances not assumed			-.830	258.089	.407

It was revealed from the independent sample test in Table 5 with a p – value (sig 2-tailed) of 0.407 that there is no significant difference between the ATMI scores of the control group and the experimental group before the intervention. This means that the two groups have the same perception towards mathematics before they were taught of the same lessons using different teaching strategies.

Table 6. Comparison of the Mean Scores of the Pre-test and Post-test Scores of the Control Group

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Posttest	9.4733	131	3.05923	.26729
	Pretest	4.2977	131	1.82586	.15953

Table 6 shows that the mean pre-test scores of the control group is 4.2977 with a standard deviation of 1.82586 while the post test scores is 9.4733 with standard deviation of 3.05923. The means of the pretest scores and the post test scores showed a difference of 4.4963. To determine if such difference is significant, a paired samples t-test was conducted.

Table 7. Paired Samples Test - Pre test – Post test Scores of the Control Group

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std Deviation	Std Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Post test Control Pre test Control	5.17557	3.44736	.30120	4.57969	5.77146	17.183	130	.000

The results of the paired samples test in Table 7 shows that the mean scores of the control group before and after the intervention is significantly different at p-value of 0.000 (Sig 2-tailed) with the mean score of the post-test being higher. Results implied that learning took place using the traditional method.

Table 8. Comparison of the Mean Scores of the Pre test and Post test Scores of the Experimental Group

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Post-test _Exp	12.0305	131	1.98819	.17371
	Pre tsetse	4.5496	131	2.08738	.18237

Shown in Table 8 is the mean score and standard deviation of the pre-test of the experimental group given before they were taught of the same lessons with the integration of GeoGebra are 4.5496 and 2.08738 respectively while the mean score of the post-test given to the samples after the intervention is 12.0305 with a standard deviation of 1.98819. The pre test and the post-test given to the experimental group has a mean difference of 7.4809 in favor of the post test.

Table 9. Paired Samples Test - Pre-test – Post test Scores of the Experimental Group

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std Deviation	Std Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Post-test Control Pre-test Control	7.48092	2.94658	.25744	6.97159	7.99024	29.058	130	.000

Results of the paired sample test conducted as shown in Table 9 revealed that there is significant difference between the mean scores of the post-test and pre-test of the experimental group at a p- value of 0.000. This result showed that the integration of GeoGebra in teaching calculus has a positive effect to the students' performance in calculus.

Table 10. Comparison Between the ATMI Scores of the Control Group Before and After Teaching Using Conventional Method

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	ATMI Scores Before - Control	139.1603	131	18.36377	1.60445
	ATMI Scores After - Control	140.1603	131	19.74679	1.72528

The ATMI mean scores of the control group before and after the intervention are 139.1603 and 140.1603 respectively as shown above in Table 10. This made a very little difference of 1.000. These computed means made some standard deviations before and after the intervention as 18.36377 and 19.74679 respectively.

Table 11. Paired Samples Test - ATMI Scores of the Control Group

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std Deviation	Std Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pair 1 ATMI Scores Before - ATMI Scores After	-1.0000	18.02520	1.57487	-4.11569	2.11569	- .635	130	0.527

The results of the paired samples test with a p – value of 0.527 revealed that there is no significant difference between the ATMI scores of the control group before and after the intervention. This showed that the use of conventional method of teaching did not affected the attitude of the students towards mathematics.

Table 12. Comparison Between the ATMI Scores of the Experimental Group Before and After the Teaching Experiment

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	ATMI Scores Before - Experimental	141.1298	131	20.01822	1.74900
	ATMI Scores After - Experimental	145.3359	131	19.51828	1.70532

The ATMI mean scores of the experimental group before and after they were taught of the same lessons using a teaching method with GeoGebra integration are 141.1298 and 145.3359 respectively as shown in Table 12. These mean scores gave standard deviations of 20.01822 and 19.51828.

Table 13. Paired Samples Test - ATMI Scores of the Experimental Group

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std Deviation	Std Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pair 1 ATMI Scores Before - ATMI Scores After	4.20611	12.72412	1.11171	2.00672	6.40550	3.783	130	0.000

With a p – value of 0.000, it was revealed from the paired samples test that the ATMI scores before and after the intervention has significant difference as shown in Table 13. This result implied that teaching calculus with GeoGebra integration greatly affected the attitude of the students toward mathematics in positive manner.

Table 14. Comparison Between the Post Test Scores of the Control Group and the Experimental Group

Grouping Variable		N	Mean	Std. Deviation	Std. Error Mean
Post Test Scores	Control	131	9. 4733	3.05923	0.26729
	Exp	131	12. 0305	1.98819	0.17371

Table 15. Levene's test of equality of Variance – Independent Sample Test

		. Levene's test of equality of Variance		t- test for equality of means		
		F	Sig	t	df	Sig (2-tailed)
Pretest Scores	Equal variances assumed	36.647	0.000	- 8.022	260	0.000
	Equal variances not assumed			- 8.022	223.191	0.000

Table 14 shows that the post-test mean scores of the experimental group is higher compared to that of the control group (12. 0305 vs 9. 4733). Similarly, the scores in the experimental group is more coherent (concentrated near the mean) with a standard deviation of only 1.98819 compared to that of the control group of 3.05923. Results of the independent samples test in Table 15 shows that at a p-value of 0.000 there exists significant difference between the post test scores of the control group and the experimental group in favor of the experimental group. This implies that the integration of GeoGebra in teaching geometric solutions in calculus can better improve the performance of the students in calculus than the use of the conventional method.

Table 16. Comparison Between the ATMI Scores of the Control Group and the Experimental Group After the Intervention

		N	Mean	Std. Deviation	Std. Error Mean
Post Test Scores	Control	131	140.1603	19.74679	1.72528
	Exp	131	145.3359	19.51828	1.70532

Table 17. Levene's test of equality of Variance – Independent Samples Test

		Levene's test of equality of Variance		t- test for equality of means		
		F	Sig	t	df	Sig (2-tailed)
Pretest Scores	Equal variances assumed	1.118	0.291	- 2.134	260	0.034
	Equal variances not assumed			- 2.134	259.985	0.034

As shown in Table 16, the ATMI mean scores of the experimental group (145.3359) is higher compared to that of the control group (140.1603). These mean scores reflected standard deviations of 19.51828 and 19.74679. At first glance, these figures seem to show almost the same distribution. But after conducting the independent samples test, at 0.05 level of significance, it was revealed that the ATMI scores of the experimental group and of the control group exists a significant difference. This implies that the use of the teaching method with GeoGebra integration posters positive effect to the students' attitude towards mathematics.

With the findings, the researchers looked at how the intervention affected the four basic aspects taken into account by the ATMI. These four factors were named by Tapia as the students' self-worth, sense of purpose, motivation, and enjoyment.

Table 18. Comparison of the ATMI Scores of the Control Group and the Experimental Group on Each of the Four Factors Considered in the ATMI (After the Intervention)

		N	Mean	Std. Deviation	Std. Error Mean
Confidence Scores	Control	131	47.8779	9.01348	0.78753
	Experimental	123	51.1545	9.40878	0.84836
Motivation Scores	Control	131	22.0763	3.42529	0.29927
	Experimental	131	22.9466	3.10660	0.27142
Value Scores	Control	131	28.0992	4.24056	0.37050
	Experimental	129	29.0698	3.83281	0.33746
Enjoyment Scores	Control	131	31.9466	6.45733	0.56418
	Experimental	127	33.4173	5.01180	0.44473

Table 19. Levene's test of equality of Variance

	Levene's test of equality of Variance	t- test for equality of means				
		F	Sig	t	df	Sig (2-tailed)
Confidence Scores	Equal Variances Assumed	0.849	0.358	-2.834	252	0.005
	Equal Variances Not Assumed			-2.831	249.196	0.005
Motivation Scores	Equal Variances Assumed	0.413	0.521	-2.154	260	0.032
	Equal Variances Not Assumed			-2.154	257.559	0.032
Value Scores	Equal Variances Assumed	0.171	0.679	-1.935	258	0.054
	Equal Variances Not Assumed			-1.937	256.133	0.054
Enjoyment Scores	Equal Variances Assumed	0.057	0.812	-2.039	256	0.042
	Equal Variances Not Assumed			-2.047	244.393	0.042

After collecting all the score responses for the 16 items that composes the confidence factor of the ATMI given to samples after the intervention, data on Table 18 shows that the mean score of the experimental group is higher than that of the control group (51.1545 vs 47.8779). This difference is found to be significant after conducting an independent samples test. This indicates that the experimental group who experienced technology integration gained more confidence in studying and learning mathematics compared to those of the control group who underwent conventional teaching.

The mean scores of the 6 items comprising the motivation factor in the ATMI of the experimental group and the control group after the intervention are 22.9466 and 22.0763, respectively, while the mean scores of the 9 items of the enjoyment factor of the inventory used to the two groups are 33.4173 and 31.9466. As reflected in the results of the data in Table 19, at 0.05 level of significance, it was found that there exists a significance difference between the mean scores of the experimental group and control group on both motivation and enjoyment factors. This revealed that after the intervention the experimental group expressed greater desire to study and learn mathematics compared to the control group. Similarly, it was also revealed that the experimental group found more enjoyment in calculus class than the control group during the experiment. The study showed that the integration of GeoGebra in teaching calculus can motivate students to study mathematics and increase their enjoyment in learning and working with math.

Considering the perceived valuing of mathematics of the students, the mean scores of the 9 item – value of math factor given by the experimental group and the control group after the intervention are 29.0698 and 28.0992. These mean scores reflected standard deviations of the two groups as 3.83281 and 4.24056 respectively. The summary of the results of the independent samples test shown in Table 19 revealed that there exists no significant difference between the ATMI mean scores under the value dimension of the experimental group and the control group. This indicates that both groups have the same valuing of calculus in their lives and that the integration of GeoGebra in teaching lessons did not gave effects on the students' perception of the importance and relevance of mathematics in their lives.

Table 20. Students' Performance on Worksheet of Plane Areas

	Number of Students					Total
	Solved Problem No.1 only	Solved Problem Nos. 1 & 2 only	Solved Problem Nos. 1, 2 & 3 only	Solved Problem Nos. 1, 2 & 3 & were able to graph, form equation of area on Problem 4	Solved Problem Nos. 1, 2, 3 & 4	
Control Group	3	91	33	3	1	131
	2.29%	69.47%	25.19%	2.29%	0.76%	100%
Experimental Group	0	0	42	63	26	131
	0%	0%	32.06 %	48.09%	19.85%	100%

Part of the lesson plan developed for the experiment was a worksheet consisting of four (4) problems on plane areas of intersecting curves. The students were given forty - five (45) minutes to work on the problems with the experimental group using GeoGebra as an option while the control group doing them manually. Table 20 shows how the two groups performed. Three (3) students in the control group were able to solve number 1 problem only. Ninety- one (91) students solved problem numbers 1 and 2 only composing 69.4 % of the control group while 33 students or 25.19% of this group were able to solve problem numbers 1, 2 and 3 only. Only 3 students were able to solve problem numbers 1, 2 and 3 and had graphed and formed equation of the area of the region in problem number 4. This making 2.29% of the group almost finished solving the problems. And there was one (1) student in the group who was able to completely solve the four (4) problems in the given worksheet.

It is good to note that nobody in the experimental group was able to solve problem number 1 only or even problem numbers 1 and 2 only. Forty- two (42) students or 32.06% of this group were able to solve problem numbers 1, 2 and 3 only. While their 63 students aside from solving problems 1, 2 and 3 were also able to graph, and form equation of plane area for problem number 4. This indicates that 48.09% of the group almost finished the four problems. And it is remarkable to note that 26 or 19.85% of the experimental group against 1 or 0.76% of that of the control group completely solved the four (4) problems in the worksheet.

Students' Insights of Using GeoGebra During Calculus Lessons

Table 21. Advantages and Disadvantages of Using GeoGebra in Calculus Class According to the Students

Advantages of Using GeoGebra	**Disadvantages of Using GeoGebra**
Reliable and made graphing easier	A problem for students with no cellphone.
It makes problem solving in calculus easier	It makes the students lazy.
The graph can be visualized accurately, can be in different colors	Not advisable to use in exams.
You are being inspired to try solving	You will not experience to plot graphs manually.
You can easily understand the concept of the lesson.	Makes you dependent to technology
Enjoyable.	
Hassle free in graphing which helps you focus on calculus concepts.	
This mobile application is effective in learning plane areas.	
Less time was consumed in graphing and gave more time to think about the concept of calculus needed to solve the problems.	
Fast to solve problems	

Focus group discussion was organized from those students who experienced using GeoGebra during calculus lessons. Table 21 summarizes the comments of the students during the FGD. Students found the use of GeoGebra reliable and makes graphing easier. They see the use of this mobile apps as a tool that makes graphing accurate, hassle free and not time consuming. The students observed the help of GeoGebra to make calculus concepts understandable and tooled them to solve problems faster. For most of them, the use of GeoGebra was found to be enjoyable and inspiring to try solving problems. They found this apps effective in learning solutions of plane areas.

Though observed advantages were great, students feel some apprehensions in using GeoGebra in class. They saw the problem of students without mobile phones. Not all students can buy mobile phones. They also see the use of this apps disadvantageous for making the students lazy in studying, dependent to technology and would not be able to experience graphing manually. And they thought that the use of this apps is not ideal during examinations.

CONCLUSION

Based on the aforementioned findings, the following conclusions were formed:

1. The pretest mean scores of the control group and the experimental group do not differ significantly.
2. There exists no significant difference between the ATMI mean scores of the control group and the experimental group before the use of GeoGebra.
3. There exists significant difference between the pre-test and post test scores of the control group likewise significant difference is also noted for the experimental group.
4. The ATMI scores before and after the experiment showed no significant difference for the control group but significant difference was revealed for the experimental group.
5. The post test scores of the control group and the experimental group have significant difference in favor of the experimental group for getting higher achievement scores.
6. There exists significant difference between the ATMI scores of the control group and the experimental group after the experiment.
7. The results of the analyses of the four factors of the ATMI scores between the control group and the experimental group after the experiment showed significant differences in their confidence factor, motivation factor and enjoyment factor but no difference exists in their value factor.
8. Results showed that there is an improvement in the performance of both groups, but significant improvement was shown for the students who were exposed to the teaching of calculus with GeoGebra integration. The experiment was conducted only for two (2) weeks and due to this limitation, the results cannot be generalized. Nevertheless, this could encourage other researchers to conduct parallel studies taking into consideration this limitation.
9. The attitude towards mathematics of the students exposed to GeoGebra were enhanced with no effect on the students exposed to the conventional method. Further analyses showed that the students exposed to GeoGebra enhanced their confidence of their performance in mathematics, found more enjoyment in dealing with mathematics and increased their desire of studying mathematics. But then, it was also shown that this GeoGebra integration has no effect on the students' valuing of mathematics. They made no effect on the students' perception of the importance and relevance of mathematics in their lives.

RECOMMENDATIONS

1. Similar action research must be conducted to make further validation of the research findings. Different technologies or applications must also be considered depending on the need and its suitability to classroom instruction.
2. Teachers must continuously make updates on technology and innovation to keep abreast of the fast-changing pace of the Information age. Learn everything applicable to teaching and learning.

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