

The Effectiveness of Geogebra in the Teaching of Elementary Algebra at St Teresa's College of Education Ghana

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Abstract – This study investigated the effectiveness of Geogebra-Plus-Lecture model on the Elementary Algebra Achievement of the students at St Teresa's College. The Posttest only experimental design was adopted. A total of 58 students took part in the study. The average age of the students was 23 years. A researcher-designed Elementary Algebra Test (EAT) was used for data collection. The EAT was validated by experts in Mathematics Education. The study was guided by two research questions and two hypotheses. The research questions were answered using mean and standard deviation whereas the Analysis of Variance (ANOVA) was used to test the hypotheses. The findings established that: there was a significant effect of Geo-Gebra-Plus-Lecture Model on the Elementary Algebra Achievement of students ($F_{1, 56}=4.260, p<.05$) and the age of students did not influence their learning achievement in Elementary Algebra ($F_{1, 28}=.370, p>.05$). It was recommended that Mathematics tutors should expose students to more problem-solving classrooms supported by mathematical software such as Geogebra and Sketch Pad among others to help the learners in their learning process

Keywords – ICT, Algebra, Concept, Understanding, College of Education.

I. INTRODUCTION

Basic Algebra skill is important in the teaching and learning of Mathematics. Being an expert of the discipline means mastery of the basic Algebra structure. This would mean more practice as well as increased exposure to the basic rules in Algebra as it is considered to support other aspects of Mathematics, such as Geometry, Trigonometry, Statistics, etc due to the horizontal integration of the Mathematics curriculum. On vertical integration of the curriculum, as an individual grows and moves up the educational ladder, mastery of skills is required as subjects become tougher and more complicated. The level of content difficulty is expected to increase. Students nowadays are becoming reluctant to apply the knowledge gained from Mathematics as a whole. Senior high school students from different schools in Ghana

are having hard times to deal with mathematical rules and applications.

Algebra is an aspect of the General Mathematics designed to help students solve certain types of problems quicker and easier. Algebra is based on the concept of unknown values called variables, unlike arithmetic which is based entirely on known number values. (Wyzant, Inc., 2005 – 2019). Understanding Algebra seems tricky at first, but if the students build up a strong basic knowledge of the mathematical facts and learn the “language” of Algebra, they can understand it much more easily (Cam, March 2019). Students learn how to describe relationships with a variety of representations and how to make relations among these representations. The goal is not to just learn the structure and symbols of Algebra, but to also use it as a tool to solve

problems that arise in the real world. To use Algebra effectively students must be able to make reasonable choices about which algebraic representation, if any, to use in solving a problem (id).

According to the National Council of Teachers of Mathematics: Commission on Standards for School Mathematics (1989), the philosophy of the Mathematics programme is guided by the following principles:

- ✓ Mathematics is a human activity for all.
- ✓ The real-world contexts support and motivate learning.
- ✓ Models help students learn Mathematics at different levels of abstraction.
- ✓ Students reinvent significant Mathematics.
- ✓ Interaction is essential for learning Mathematics.
- ✓ Valuing multiple strategies is important.
- ✓ Teachers and students assume different roles.
- ✓ Students should not move quickly to the abstract.
- ✓ Mastery develops throughout the curriculum.
- ✓ Mathematics is often new and different.

Learning is ideal when teachers can utilize tools that support motivation, empowerment, self-efficacy, and that provide challenges of appropriate greatness and complexity. Using ICT to teach Mathematics and its structure is one way to help students become familiar with its basic rules. This could be done every day before the beginning of the daily lesson. Tutors spare 10-15 minutes of regular Mathematics lesson to intensify ICT to review the basic Algebra rules and its applications. The use of ICT in the classrooms provides the opportunity for teachers to give the students the response that supports their learning efforts and encourages strong working relationships between students and teachers. Students benefit from having set goals, being vested in their learning, and attain the confidence to share their success and present their difficulties and challenges. The outcomes of Crisan, Lerman & Winbourne (2007) unfold those new dimensions to understanding teachers' use of ICT by discussing the teaching of Mathematics and ICT utilization as entangled features of a teacher's practice. A framework which conceptualises teachers' learning about ICT and teachers' incorporation of ICT in their teaching of

Mathematics is advanced to contribute to a better understanding of the pedagogy of teaching Mathematics with ICT. Handal and Herrington (2003) revealed that common beliefs were very convincing on the teachers' daily pedagogical decisions and that their beliefs about the nature of Mathematics served as a primary source of their beliefs about pedagogy and student learning.

Studies point to a positive impact of ICT utilization in different subject areas under explicit situations and contexts. According to Harrison et al. (2002), there is a positive relationship between the use of ICT and pupils' performance. Nakhleh and Krajcik (1994) also found that ICT use supports the development of the concept in teaching and learning of Science. Another study from Tüzün *et al.* (2009) shows that there is a relational effect of computer games on basic pupils' performance and also helps motivate pupils to learn. Their findings show that pupils were independent in their active participation in the game-based activities for understanding rather than their concentration on grades. Jimoyiannis & Komis (2001), however, used electronic simulations to teach concepts in Physics. They found that using simulations increases the pupils' performance in the learned subject. They, therefore, concluded that using electronic simulations could be an alternative teaching method which cultivates a purposeful understanding of physical concepts.

Some researchers explored the impact of ICT on Mathematics teaching and learning. According to Becta (2003), the precise benefits of using ICT are that: It intensifies collaboration among pupils and encourages communication and knowledge sharing; it also enables quick and accurate feedback for the pupils which as a result leads to positive motivation; it, however, allows the pupils to focus on approaches and clarifications of answers instead of wasting time on excessive computations; and it also supports useful pedagogy, that is, the pupils use ICT to realize mathematical ideas and deeply understand them. The National Council of Teachers of Mathematics (NCTM, 2000) points at technology as essential for the teaching and learning of Mathematics because it affects the Mathematics that the teacher teaches and the pupils learn, and it improves the pupils learning. The NCTM also declares that pupils who use technology learn more Mathematics in-depth. It is deduced that NCTM and Becta maintain that technology is an enabling tool, as well as inspiring students to concentrate on reflection, verification, decision-making and problem-solving in all disciplines particularly in Mathematics teaching and learning.

Computer-Assisted Instruction (CAI) is the utilization of the personal computer to help in conveying the topic (Seo &

Bryant, 2012). The PCs and projects that accompany the guidance can give utilization of a wide range of sorts of hands-on circumstances with the dash of a mouse. A few projects will have devices that are not as easy to understand or require a short instructional exercise on step-by-step instructions to utilize them accurately. Likewise, with most introductions to something new, more practice with the instrument will permit the students to turn out to be progressively acquainted with its idea and the use of the apparatus in their work.

CAI Facilitation Math Explorer utilizes four subjective procedural steps: Reading, Finding, Drawing, and Computing. They likewise kept on posting the metacognitive strides as doing the movement, getting some information about the circumstance, and checking to ensure the students comprehend (Seo & Bryant, 2012). Math Explorer uses the gadgets in the room as a program-related critical thinking methodology. The utilization of projects and (applications) on gadgets is developing. Discovering which applications are the most helpful to use, alongside which setting to utilize them, is significant. Each student will have changing degrees of fitness. Utilizing applications to bring the most fitting data to them is indispensable to their learning.

WebQuest programme helps students to work at their determined material while instructors can assist with motivating students to take part (Hakverdi-Can & Sonmez, 2012). The WebQuest permits students to use reenactments and work with genuine information that can be tried in different things with by the students. Students reacted that the instructing and picking up utilizing Telegram permit them to increase new understanding, be progressively inventive, produce unconstrained thoughts, give genuine thoughts without the danger of being embarrassed and urge them to be energized just as enthusiastic with their learning. Contrasted and ordinary classes, all students can give thoughts and the thoughts were straightforward without anyone else (Zanaton & Sumaiyah, 2017).

Cacace (2019) inspected the impacts of Google Classroom on the results of students with learning disabilities in the Science. Results show that students improved their association when Google Classroom was being utilized. Notwithstanding, student achievement didn't show a lot of progress. The student performance study recommends that learners were not energetic about utilizing Google Classroom to finish assignments yet favoured it for monitoring assignments. Hemrungrrote et al., (2017) explored student satisfaction in utilizing Google Classroom. From their examination, it was uncovered that even though the

information doesn't demonstrate an expansion in student reviews, most of the students indicated satisfaction in the usage of Google Classroom in the course. Google Classroom permits instructors to execute exercises utilizing numerous instructional methodologies, which as proposed by Gersten et al. (2009). This was proven to be useful for students with learning disabilities. It was recommended that Google Classroom positively affects student satisfaction (Hemrungrrote et al., 2017; DiCicco, 2016). Predictable consolidation of Google Classroom permits exercises to become student-driven, assisting with making more self-determination. Students figure out how to incorporate the abilities from the course into different courses in their training (Hemrungrrote et al., 2017).

Yismaw and Gurju (2018) stated that in an interconnected world, integrating technology into the teaching and learning of Mathematics addresses the learning needs and interests of many of our pupils. Technology influences our students' learning styles. They prefer to see, to touch, and experience the topics they encounter in the school through modelling, simulation, and visualization (Akçay, 2017). Technology makes it possible for teachers and students to communicate traditionally abstract concepts in conceptually rich, accessible ways (Abramovich, 2013). Technology also gives opportunities for students to construct knowledge and explore new methods of problem-solving (Bray & Tangney, 2017). Technological literacy is an essential skill that should be encouraged in the Mathematics classroom (Mainali & Key, 2012). Teachers need a deep understanding of the mathematical technologies at their disposal to fully exploit their possibilities to design tasks that fully engage students to learn (Sherman, 2014).

Caligaris et al. (2015) opined that GeoGebra is handy, with an easy to use interface and apparatuses that empower instructors to make taking in materials that range from straightforward diagrams to dynamic website pages. Generally, innovative tools have assumed a significant role in the instructing of Mathematics, composing tablets, and physical manipulative to adding machines, PCs, intuitive whiteboards, and so forth (Akçay, 2017). Analysts have noticed that incorporating GeoGebra in the Arithmetic classroom can build learner performance at all degrees of instruction while empowering the improvement of abilities fundamental for work and cultivating dynamic learning (Yismaw & Gurju, 2018). A study by Momanyi, Too and Simiyu, (2015) established that age had a significant effect on the student academic performance whereas Ebinuwa-Okoh (2010) maintains that there was no significant difference in academic performance of students based on age.

Problem specification

Despite the remarkable benefits of using ICT in enhancing students' learning of Mathematics by providing a great opportunity for visualization, manipulation, and exploration of mathematical concepts, a considerable number of students are still struggling with the task of effectively using it for everyday learning. Even though students have access to smartphones and appropriate software is available all over, technology is rarely integrated substantially into everyday learning. Some studies show that teachers' know-how from both technical and pedagogical arguments have a significant influence on their intention to use technology.

Assessment reports by the Department of Mathematics and ICT Education for the two successive academic years indicate that Algebra in general and Word problem, in particular, were major contributors to students' underachievement in Mathematics courses. The present study investigates the impact of intensified ICT teaching on PE2 student Elementary Algebra achievement. The emphasis is to discover whether the GeoGebra-plus-Lecture method enhances the student problem-solving skills and in due course improves their achievement in Elementary Algebra.

Aim and objectives

The study aims to determine the effectiveness of GeoGebra-plus-Lecture in the improvement of Elementary Algebra learning achievement of the Pre-service teachers at St Teresa's College of Education, Hohoe, Ghana. Specifically, the objectives of the study are to:

1. determine the effect of GeoGebra on the Elementary Algebra learning achievement of the Pre-service teachers
2. find out the difference in the Elementary Algebra learning achievement of Pre-service teachers based on age

Research questions

The following research questions guided the study:

1. What is the effect of GeoGebra on the Elementary Algebra learning achievement of the Pre-service teachers?
2. What is the difference in the Elementary Algebra learning achievement of Pre-service teachers taught using GeoGebra based on age?

Hypotheses

The following hypotheses were tested at .05 level of significance:

H₀₁: There is no significant difference between the mean scores of students taught Elementary Algebra with Geogebra as a supplemental model with and those taught without Geogebra

H₀₂: There is no significant difference between the mean scores of the students in the age brackets of 18-22 years and those in the age range of 23-27 years taught with Geogebra.

II. METHODS AND MATERIALS

Research design: This study aims to determine the effectiveness of intensified ICT in developing the concept of Elementary Algebra among the PE2 students at St. Teresa's College of Education, Ghana. The study adopted a quasi-experimental design. Posttest only Quasi-experimental design was considered appropriate because the study sought to investigate the effect of GeoGebra-plus-lecture model on the Elementary Algebra learning achievement of Pre-service teachers. The study was to determine whether the use of GeoGebra as a supplemental instructional tool leads to improved student achievement in Elementary Algebra. The ethical issues were considered since the lesson was conducted during the school instructional time.

Participants

A total of 58 students took part in the study. There were 30 students in the experimental group and 28 students in the control group. The average age of the students was 23 years. All the 30 students in the class assigned to the experimental group participated in the study whereas the only 28 randomly selected students participated in the class assigned to the control group.

Instrumentation: The instrument for data collection was a 13-item Elementary Algebra Test (EAT). It was used to measure student achievement in Elementary Algebra. The EAT had two sections. Section A had 10 multiple choice questions whereas section B had 5 essay type questions, which students had options to select only 3 questions from the set. The EAT was validated by experts. The reliability of EAT was determined using Kuder-Richardson, KR-21 and obtained a coefficient of 0.81.

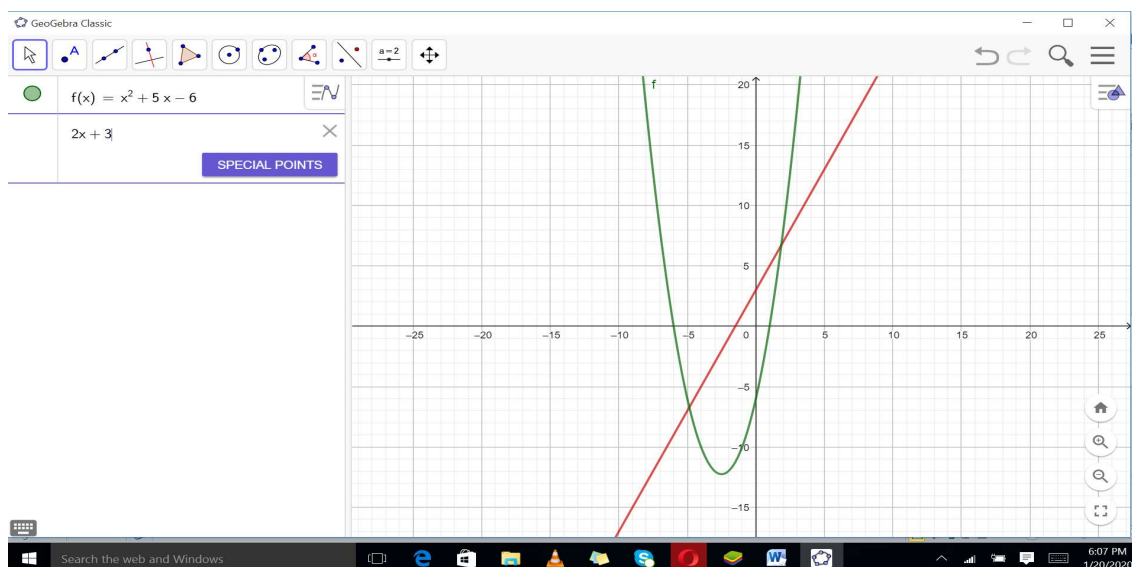
Experimental procedures

The teachers who took part in the study were given orientation on the theoretical and practical aspect of the adopted instructional models in the classes. The students in both the experimental and control groups participated in the learning episode, but with different models of instructions adopted in each group. At the end of the learning episode, the students in both groups also took a posttest on EAT.

Intervention group: A trained teacher facilitated the instructions in the experimental group. In all, four lessons were carried out using Geogebra software package as a supplemental strategy to lecture method. A posttest was administered. The aim was to measure the Primary Education level 100 gains in Elementary Algebra. A total of 30 students completed the task in the experimental group. The software has a variety of functionalities. GeoGebra could be used in

drawing figures, lines and function and graphs, calculating or measuring angles, lengths, area, circumferences, maximum and minimum of a function. GeoGebra could also be used as an unconventional calculator but not only. It can operate on vectors, matrices and even solve quadratic equations and a system of linear equations. Shown below is the capabilities of GeoGebra.

Example 1: Solving linear and quadratic equations using Geogebra



Control group: The students in the control group also used the same module and solved the same number of problems encountered in the experimental group. The traditional instructional model was adopted in this group.

Data Analysis: The research questions were answered using mean and standard deviation whereas the hypotheses were tested using the Analysis of Variance (ANOVA) at .05 level of significance

III. RESULTS

Table 1: Summary of mean scores of students taught using GLM and those taught using the traditional model.

		GeoGebra-Plus-Lecture model, n=30		Traditional Instructional model, n=28	
		Statistic	Std. Error	Statistic	Std. Error
Mean		67.87	1.39	63.89	1.32
95% CI	Lower Bound	65.01		61.19	
	Upper Bound	70.72		66.60	
Median		68.00		65.50	
Std. Deviation		7.64		6.98	
Minimum		55.00		51.00	
Maximum		82.00		82.00	

The results from Table 1 show that mean score of students taught Algebra using GeoGebra-Plus-Lecture model was 67.87, SD=7.64; their 95% confidence interval ranged from

65.01 to 70.72 whereas the mean score of those taught using the traditional instructional model was 63.89, SD=6.98 with their 95% CI moving from 61.19 to 66.60.

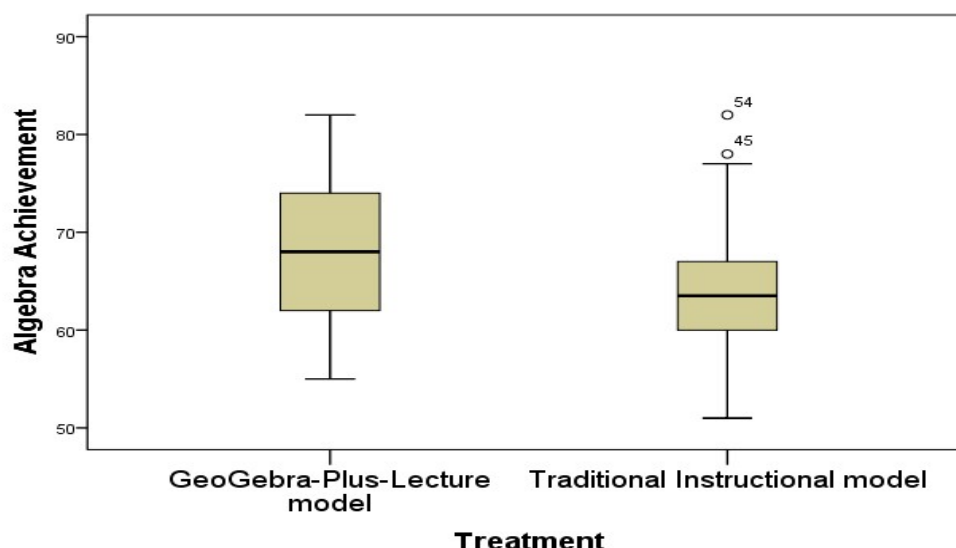


Fig. 1: Box plot

The boxplot of the Algebra achievement was plotted against the treatments in Figure 1. There were two outliers in the control group. The boxplot had mid 50% and each whisker connotes the lower and upper 25% of the cases. Consequently, the lower 50% of the Algebra achievement of the students who were taught using GeoGebra-Plus-Lecture

model ranged between 55.00 and 68.00 whereas the upper 50% ranged between 68.00 and 82.00. The lower 50% of the Algebra Achievement among students taught using the traditional method ranged between 51.00 and 63.50 whereas the upper 50% ranged between 63.50 and 82.00.

Table 2: Summary of mean scores of students taught using GLM based on age

		18-22 years, n=12		23-27 years, n=18	
		Statistic	Std. Error	Statistic	Std. Error
Mean		68.92	2.38	67.17	1.74
95% Confidence	Lower Bound	63.69		63.50	
Interval for Mean	Upper Bound	74.15		70.83	
Median		71.50		67.00	
Std. Deviation		8.23		7.37	
Minimum		56.00		55.00	
Maximum		78.00		82.00	

The results from Table 2 show that mean score of students taught Algebra using GeoGebra-Plus-Lecture model who was in the age bracket of 18-22 years was 68.92, SD=8.23; their 95% confidence interval ranged from 63.69 to 74.15

whereas the mean score of those in the age bracket of 23-27 years in the same group was 67.17, SD=7.37 with their 95% CI moving from 63.50 to 70.83.

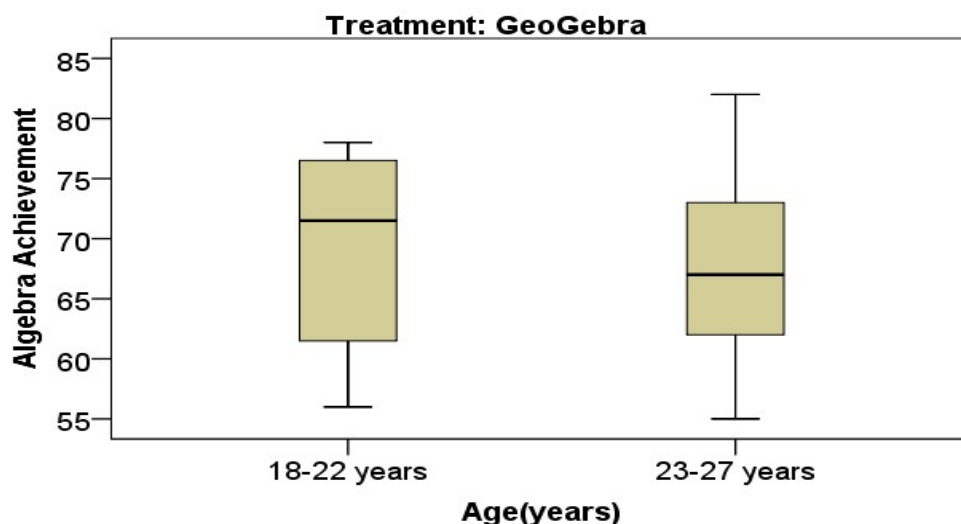


Fig. 2: Box plot based on age

The boxplot of the Algebra achievement was plotted against student age in Figure 2. There were no outliers. The boxplot had mid 50% and each whisker connotes the lower and upper 25% of the cases. Consequently, the lower 50% of the Algebra Achievement of the students who were taught using GeoGebra-Plus-Lecture model and in the age bracket

of 18-22 years was 56.00 and 71.50 whereas the upper 50% ranged between 71.50 and 78.00. The lower 50% of the Algebra Achievement among students taught using the same method but in the age bracket of 23-27 years was ranged between 55.00 and 67.00 whereas the upper 50% ranged between 67.00 and 82.00.

Table 3: Summary of univariate Analysis of Variance (ANOVA) of the main effect of treatment on the Algebra achievement of the students

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	228.700 ^a	1	228.700	4.260	.044
Intercept	251428.975	1	251428.975	4683.747	.000
Treatment	228.700	1	228.700	4.260	.044
Error	3006.145	56	53.681		
Total	255487.000	58			
Corrected Total	3234.845	57			

a. R Squared = .071 (Adjusted R Squared = .054)

The result from Table 3 shows the summary of one-way Analysis of Variance (ANOVA) of the main effect of treatment on the Algebra achievement of the students. It shows that there is a significant difference between the mean

scores of students taught Algebra with Geogebra as a supplemental model and those taught without Geogebra ($F_{1,56}=4.260, p<.05$). The null hypothesis one was rejected at .05 alpha level.

Table 4: Summary of univariate Analysis of Variance (ANOVA) of the main effect of age on the Algebra achievement of the students in the experimental group

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	22.050 ^b	1	22.050	.370	.548
Intercept	133334.450	1	133334.450	2236.329	.000
Age	22.050	1	22.050	.370	.548
Error	1669.417	28	59.622		
Total	139868.000	30			
Corrected Total	1691.467	29			

The result from Table 4 shows the summary of univariate Analysis of Variance (ANOVA) of the main effect of age on the Algebra achievement of the students in the experimental group. It shows that there is no difference between the mean scores of the students in the age brackets of 18-22 and 23-27 years of the experimental group ($F_{1, 28}=.370, p>.05$). The null hypothesis two was retained at .05 level of significance.

IV. DISCUSSION

The effectiveness of GeoGebra-plus-lecture instructional model on the Elementary Algebra learning achievement

The result from Table 1 and Figure 1 showed that the GeoGebra-plus-lecture model was able to improve the learning of the students in the experimental group more than the control group with a mean difference of 3.98. The two groups had equivalent maximum scores but different minimum scores, though higher in the experimental group. This showed that there was a meaningful gain in knowledge of Elementary Algebra in the first semester. The students of College of education found the content taught somewhat difficult, but after several sessions of intensified use of GeoGebra as a supplemental strategy in the teaching of Mathematics, their knowledge of the concept of Elementary Algebra developed over time. When put to the statistical test, the result from Table 3 showed that there is a significant difference between the mean scores of students taught Algebra with GeoGebra as a supplemental model and those taught without GeoGebra ($F_{1, 56}=4.260, p<.05$). This lends credence to the rejection of hypothesis one at .05 level of significance. The findings of the study, therefore maintain that the use of intensified ICT can help students in colleges of education to improve their mathematical concepts. Lim and Tay (2003), explored the use of ICT tools to engage students and observed higher student engagement in higher-order thinking skills. It enables teachers to become better managers of a class or good facilitators who give the ability to provide opportunities for students to develop and craft

ideas over some time, and in several independent practice and learning, makes critics an ideal tool to encourage and support students at all levels. The GeoGebra was used as a supplemental strategy in the lecture classroom. This was supposed in the words of Kelleher (2000) who opined that ICT use in teaching cannot and will not substitute teachers in the classroom, but can only promote understanding and retention of content learnt and enabling learners to go beyond the stated area of study. Peter (2015) indicated that there are significant differences due to flexibility and focused interest in classes where ICT was integrated. It was concluded that ICT use in Mathematics teaching brings about a better understanding of concepts and skill transfer from abstract to concrete. The uses of ICT in teaching and learning of Mathematics helped to overcome limitations of abstraction, hence impacted positively on the performance in the test scores.

Geogebra and age-associated learning achievement in Elementary Algebra

The result from Table 2 and Figure 2 showed that the students in the age bracket of 18-22 years taught Elementary Algebra using the Geogebra-Plus-Lecture model slightly outperformed their counterparts in the age bracket of 23-27 years taught using the same method with a mean score of 1.75. This marginal mean difference was not significant at .05 level of significance. This finding was confirmed from the result in Table 4 which established that there is no difference between the mean scores of the students in the age brackets of 18-22 and that of 23-27 years of the experimental group ($F_{1, 28}=.370, p>.05$). The null hypothesis two was retained at .05 alpha level. Contrary to our finding on age and academic performance, Momanyi, Too and Simiyu, (2015) established that age had a significant effect on the student academic performance. However, in affirmation Ekenuwa-Okoh (2010) maintains that there was no significant difference in the academic performance of students based on age.

V. CONCLUSION

The use of GeoGebra as a support strategy to lecture proved effective in advancing Elementary Algebra learning achievement of the Preservice teachers. The improvement in the learning of the students was irrespective of their age. The use of GeoGebra as a supplemental strategy helped the students to gradually improve their understanding of Elementary Algebra. Mathematics tutors are encouraged to engage the students in the use of the GeoGebra software package in the teaching of Elementary Algebra to impact on the learning achievement of students in Mathematics.

Recommendations

Based on the findings of the study the following recommendations were made:

1. Mathematics tutors should expose students to more problem-solving classrooms supported by mathematical software packages such as Geogebra, sketch pad, derived 5 & 6, among others to help the learners in their learning process.
2. Further studies will be done in other second-semester Mathematics courses to observe the trend of the intervention.

REFERENCES

- [1] Abramovich, S. (2013). Computers in Mathematics Education: An Introduction. Computers in the Schools. <http://doi.org/10.1080/07380569.2013.765305>, 30(1-2), 4-11.
- [2] Akcay, A. O. (2017). Instructional Technologies and Pre-Service Mathematics Teachers' Selection of Technology. *Journal of Education and Practice*, 8(7), 163-173.
- [3] Becta (2003). What the research says about using ICT in Maths? Coventry: Author.
- [4] Bray, A., & Tangney, B. (2017). Technology usage in mathematics education research—A systematic review of recent trends. *Computers and Education*, 114, 255-273.
- [5] Cacace M. (2019). Effects of using Google Classroom on teaching math students with learning disabilities. Retrieved from <https://rdw.rowan.edu/cgi/viewcontent.cgi?article=3681&context=etd> on 25/01/2020
- [6] Caligaris, M. G., Schivo, M. E., & Romiti, M. R. (2015). Calculus GeoGebra, an Interesting Partnership. *Procedia—Social and Behavioral Sciences*, 174, 1183-1188.
- [7] Cam, D. (March, 2019). <https://www.wikihow.com/Understand-Algebra>
- [8] Crisan, C., Lerman, S. & Winbourne, P. (2007). Mathematics and ICT: a framework for conceptualising secondary school mathematics teachers' classroom practices. *Journal of Technology, Pedagogy and Education* 16(1) 21-39,
- [9] DiCicco, K. M. (2016). The effects of google classroom on teaching social studies for students with learning disabilities (2016). Theses and Dissertations. 1583. <https://rdw.rowan.edu/etd/1583>
- [10] Ebenuwa-Okoh, E.E. (2010). Influence of Age, Financial Status, and Gender on Academic Performance among Undergraduates, *Journal of Psychology*, 1:2, 99-103, DOI: 10.1080/09764224.2010.11885451
- [11] Gersten, R., Chard, D. J., Jayanthi, M., Baker, S. K., Morphy, P., & Flojo, J. (2009). Mathematics instruction for students with learning disabilities: A meta-analysis of instructional components. *Review of Educational Research*, 79(3), 1202-1242. Retrieved from <http://ezproxy.rowan.edu/login?url=https://search.proquest.com/docview/214121610?accountid=13605>
- [12] Hakverdi-Can, M., & Sonmez, D. (2012). Learning how to design a technology-supported inquiry-based learning environment. *Science Education International*, 23(4), 338-352.
- [13] Handal, B. & Herrington, A. (2003). Mathematics Teachers' Beliefs and Curriculum Reform. *Mathematics Education Research Journal*. 15(1), 59-69
- [14] Harrison, C., Cavendish, S., Comber, C., Fisher, T., Harrison, A., Haw, K.; Lewin, C., McFarlane, A., Mavers, D., Scrimshaw, P., Somekh, B. & Watling, R. (2002). The impact of information and communication technologies on pupil learning and attainment. Coventry: Becta/London: DfES.
- [15] Hemrungrote S., Jakkaew P. and Assawaboonmee, S. (2017). Deployment of google classroom to enhance SDL cognitive skills: A case study of introduction to information technology course. 2017 International Conference on Digital Arts, Media and Technology (ICDAMT), Chiang Mai, 2017, pp. 200-204. DOI:10.1109/ICDAMT.2017.7904961

- [16] Jimoyiannis, A. & Komis, V. (2001), Computer simulations in physics teaching and learning: a case study on students' understanding of trajectory motion. *Computers & Education*, 36, 183-204.
- [17] Kelleher, P. (2000). A Review of Recent Developments in the Use of Information Communication Technologies in Science Classrooms. *Australian Science Teachers Journal*, 46(1), 33-38.
- [18] Lim, C.P., & Tay, L.Y. (2003). Information and communication technologies (ICT) in an elementary school: Engagement in higher-order thinking. *Journal of Educational Multimedia and Hypermedia*, 12(4), 425-451.
- [19] Mainali, B. R., & Key, M. B. (2012). Using dynamic geometry software GeoGebra in developing countries: A case study of impressions of mathematics teachers in Nepal. *International Journal for Mathematics Teaching and Learning*, April 12th
- [20] Momanyi, J.M., Too, J. & Simiyu, C. (2015). Effect of Students' Age on Academic Motivation and Academic Performance among High School Students in Kenya
- [21] Nakhleh, M. B. & Krajcik, J. S. (1994). Influence of levels of information as presented by different technologies on students understanding of acids, base & pH concepts. *Journal of Research on Science Teaching*, 31(10), 1077-1096.
- [22] National Council of Teachers of Mathematics (2000). Principles and standards for school mathematics. Reston, VA: Author. 31 Jan 2007
- [23] Author: National Council of Teachers of Mathematics. Commission on Standards for School Mathematics (1989). Curriculum and evaluation standards for school mathematics. Reston, Va.: The Council, 1989.
- [24] Peter, C.B.C (2015). Master Thesis: Impact of ICT Integration on Mathematics Performance in Kenya: A Case Study of Public Secondary Schools In West Pokot County. Retrieved from <https://pdfs.semanticscholar.org/99e4/d4a2d30efb16e2e6b8709ce8633acce0b32a.pdf> on 29/11/19.
- [25] Seo, Y., & Bryant, D. (2012). Multimedia CAI program for students with mathematics difficulties. *Remedial and Special Education*, 33(4), 217-225.
- [26] Sherman, M. (2014). The Role of Technology in Supporting Students' Mathematical Thinking: Extending the Metaphors of Amplifier and Reorganizer. *Contemporary Issues in Technology and Teacher Education*, 14(3), 220-246.
- [27] Tüzün, H., Yilmaz-Soylu, M., Karakus, T., Inal, Y., & Kizilkaya, G. (2009). The effects of computer games on primary school students' achievement and motivation in geography learning. *Computers and Education*, 52 (1), 68-77.
- [28] Wyzant, Inc. (2005-2019). <https://www.wyzant.com/resources/lessons/math/algebra/equation-basics>. Retrieved 31/12/18 <https://www.wikihow.com/Understand-Algebra> Retrieved 31/12/18
- [29] Yismaw A. W. & Gurju A. Z. (2018). Capabilities and Contributions of the Dynamic Math Software, GeoGebra-a Review. *North American GeoGebra Journal*, 7(1), ISSN 2162-3856.
- [30] Zanaton H. I and Sumaiyah M. S. (2017) mobile learning: innovation in teaching and learning using telegram. 2549-8525 (Online) retrieved from <https://jurnal.uns.ac.id/ijpte/article/view/5120> on 25/01/202