Integration of Geogebra Software Into Mathematics Instruction

*O O Salami¹, E D Spangenberg¹
¹Department of Science and Technology Education, Faculty of Education, University of Johannesburg, South Africa

Article Info

Article history:
Received October 13, 2023
Revised November 14, 2023
Accepted February 11, 2024
Available Online April 30, 2024

Keywords:
Integration;
Geogebra Software;
Mathematics;
Instruction;

ABSTRACT

The study focused on how learners' performance and attitudes in mathematics were affected by the GeoGebra software. Among the most significant obstacles facing the teaching and learning of mathematics has been the need for instructional tools, particularly those incorporating information and communication technology (ICT). The design of the study was quasi-experimental with a sample size of 80 respondents selected from the population of the study with the use of a purposive sampling technique. The selection of the schools was based on the availability of working computer systems. Using basic random sampling, two intact classes were divided into experimental and control groups. The findings of the Student Achievement Test in Mathematics, SATM, indicated that pupils who had been taught GeoGebra performed significantly better at the post-test level than the pre-test level (t = 2.14; p > 0.05). The results of the Mathematics Attitudinal Scale (MAS) also demonstrated that students' attitudes toward mathematics were highly correlated with their proficiency with GeoGebra (t = 2.11; p > 0.05). The investigation concluded that there are insufficient teaching materials available for mathematics training. Thus, integrating GeoGebra software into the teaching of mathematics significantly improves secondary school students' performance in mathematics.

INTRODUCTION

Nearly everywhere in the world, mathematics is required as a topic in primary and secondary education curricula (Sun et al., 2023). The study of numbers, counting, number patterns, symbols, measuring, and quantity relationships is referred to as mathematics. It entails making precise, methodical, cautious, and logical calculations (Dahal, 2020). It is the foundation of technology and the sciences. It is essential to any country's progress as a whole. The reasons mathematics is required practically in every primary and secondary school curriculum across the globe may be traced back to its applications (Ng et al., 2023). The National Policy on Education (2023) stresses the importance of technological development out of which Mathematics cannot be left out. This is evidenced in the requirements for admission into tertiary institutions that a credit in Mathematics, as well as English Language, is required before students could be considered for admission for any course or programme (Dahal et al., 2023). According to Slavin et al. (2021), the knowledge of Mathematics can help us to measure, pay, while driving, calculate sales tax, medical measurements, and measure temperatures, while cooking, in architecture, among others (Shah et al., 2023). The ability to qualify everything observable that we interact with daily and to make plans are reasons mathematics is so vital to life. Applications of mathematics can be found everywhere, including in building construction and national economies. Thus, mathematics has greatly aided in achieving life's quick pace and
Integration of Geogebra Software Into Mathematics Instruction

https://doi.org/10.46627/silet.v5i1.343

all of its pleasures and luxuries. (Rizqi et al., 2023; Herbst et al., 2017). The learning of mathematics in secondary schools helps learners become proficient in the subject and gain computational abilities. It also helps them understand how mathematical ideas relate to developing entrepreneurship abilities for life in the broader world. Students are also taught to identify problems and translate them into mathematical terms before applying the appropriate problem-solving techniques. Finally, they are taught to be accurate to the extent that it matters to the problems at hand. Finally, they are encouraged to think logically, abstractly, and precisely. They are also encouraged to communicate their ideas through graphs and symbolic expressions. Finally, the curriculum is stimulated to become adept at thinking critically and reflectively (Fujita et al., 2021).

For use in teaching and learning mathematics in secondary schools, GeoGebra is interactive software with applications in geometry, algebra, statistics, and calculus. The system's geometry is dynamic. (Fathurrohman et al., 2021; Kim & Md-Ali, 2017). It is “Dynamic Mathematics Software (DMS) designed for teaching and learning Mathematics in secondary school and college level”, (Yorganci, 2018). GeoGebra Web Start enables you to start GeoGebra directly from the Internet, or you can download and run an installer. The software is truly platform-independent and compatible with all operating systems because it is built on the Java platform (Agyei et al., 2022; Yohannes & Chen, 2021). Despite over 55 languages, GeoGebra is an unrestricted multi-platform dynamic mathematics program for students at all educational levels that combines table, statistics, calculus, graphing, geometry, and algebra into one user-friendly package. “GeoGebra is the first among other ICT tools which are currently being explored to achieve integration of ICT in education”, (Em & Roman, 2020) disclosed. It is ICT Mathematics software designed for improved performance in the subject at the senior high school level, among others (Agyei et al., 2023; Marks et al., 2021).

GeoGebra is an intuitive, user-friendly, dynamic, interactive, open-source program focused on students. It has been extremely helpful in incorporating ICT into math education. Globally, interest in GeoGebra is expanding quickly. Jao et al. (2020) estimated that the package is accessible in more than 190 countries after analyzing the program developer (www.community.geogebra.org/it/wp-content). Among other places, math teachers in Europe, America, and Africa (Kenya specifically) have incorporated GeoGebra into their lessons. Dahal, (2020) claimed that the creation and maintenance of information retrieval, decision support system use, and dissemination were made possible by technology. Teachers now understand how important computer literacy is to their student's education. A country's technological advancement determines its level of development. Because of this, technology is now the foundation of progress and how any country can become independent and self-sufficient. (Wang et al., 2023). Mathematics will inevitably play a part in national development, not just in Nigeria but all across the world. Mathematics must advance with global trends and demand to fulfill this role. When done properly, incorporating technology into a course's curriculum can help students and the school both learn more and improve student outcomes. (Albeshree et al., 2022; Mokotjio & Mokhele, 2021).

According to the Chief Examiner of the West African Examination Council (WAEC) (2023), a significant portion of students struggled in Algebra, Number and Numeracy, and Geometry. Specifically, they made shoddy attempts at commercial arithmetic, graphic design, modifying fractions and decimals, omitting crucial information and units, premature approximation, logical reasoning, circle geometry and its applications, and modular algebra. Due to the report's complaints over the poor performance of pupils in mathematics, teachers were urged to utilize instructional materials to reinforce mathematical concepts during lessons (Feerick et al., 2022; Tang et al., 2022). Participation by teachers in the main coordination meetings was also encouraged. While complaining about the weak academic achievement of students in mathematics (Sun et al., 2023; Tang et al., 2022). The study of Ishartono et al. (2022) described the deplorable absence of enthusiasm shown by students in studying mathematics and sciences. Thapa et al. (2022) attributed the low performance in Mathematics to the following factors that
Integration of Geogebra Software Into Mathematics Instruction

https://doi.org/10.46627/silet.v5i1.343

include the attitude of the head teachers, teachers, pupils and parents (negative attitude), inadequate subject-matter mastery on the part of teachers, lack of teacher-teacher interactive opportunities, and a lack of a connection between the curriculums of primary and secondary schools (Dunngan & Halcrow, 2021; Wang et al., 2023). A lot of researchers on students' learning of Mathematics have suggested a lot of recommendations for these problems, yet little improvements are noticed in students learning of Mathematics. There is a need to integrate GeoGebra, an ICT-oriented package, for improved learning outcomes. Recent researchers reported the impact of dynamic teaching materials and packages on students' mathematical performance (Birgin & Topuz, 2021; Lo, 2019).

Lipovec et al., (2019) summarized the benefits of using instructional materials to teach and learn mathematics include: accelerating students' grasp of the material; reducing teacher talk time to make instruction more engaging and inspiring, filling the communication gap between teacher and student to make lessons more understandable to the subsequent; generating a high level of student interest, which is essential to stimulate learning as they see, handle, and touch; making mathematics more tangible rather than abstract; and providing students with the chance to use their senses to learn.

If attitudes towards Mathematics are highly favoured, it may be an indication of strong support for learning (De Vita et al., 2018; Ogbonnaya & Mushipe, 2020). The goals, convictions, and motivations a teacher brings to the classroom are essential to the teaching and learning of mathematics. By providing resources for the student to use and stimulating the student's interest in the material, an effective teacher assists a student in becoming an effective learner (Safrida et al., 2020). However, a positive attitude on the part of the students is linked to higher performance in mathematics (Mokotjo & Mokhele, 2021).

Li et al. (2022) found a direct correlation between learning outcomes and students' attitudes toward mathematics. Students' attitudes and beliefs can either help or hinder their ability to learn. Students' opinions regarding the value of education in mathematics can be seen as an input and an outcome variable since students' attitude toward the subject and their performance in it are correlated (Vinerean et al., 2022; Wu et al., 2023). Subsequently, students who perform well in a subject have a favourable attitude toward it and typically perform better in it. Meanwhile, Wassie and Zergaw (2019) opined that in-service training for the teachers and the integration of modern teaching facilities are parts of the strategies directed at improving students' attitudes towards Mathematics.

Dahal et al. (2022), noticed that “computer technology is currently easily accessible and becoming a popular teaching tool to the extent that technological literacy is now perceived as a basic skill of teaching”. The importance of using technology in Mathematics education has been emphasized by the National Council of Teachers of Mathematics (NCTM) because technology can have a crucial role in teaching and learning Mathematics: it influences the mathematics that is taught and enhances students’ learning. “Technology can then be defined as the application of scientific knowledge to provide solutions to human problems” (Dahal et al., 2023). According to the conclusions of Yorgancı, (2018) and Haleva et al. (2021), GeoGebra can give students the necessary life and career skills for the global society of the twenty-first century. Thapa et al. (2022) and Munyaruhengeri et al. (2023) also outlined some of the roles that ICT tools, such as GeoGebra, play in the teaching and learning of mathematics, particularly in secondary schools. These roles include stimulating students' interest in geometry, building on their prior knowledge and experience, improving their capacity for problem-solving and reasoning, ensuring that the curriculum is coherent and compatible with established relationships and sequences of key mathematical concepts, introducing mathematics instructional activities, and creating opportunities for students to engage deeply and sustainably with mathematics.

**Purpose of the Study**
The study examined how well students performed in mathematics using the ICT package GeoGebra. The impact of GeoGebra on students' attitudes toward mathematics was also
investigated in this study.

RESEARCH METHOD
In this research, the quasi-experimental design was used by the study. For computation, the pre-test and post-test outcomes for the experimental and control groups were acquired by the researcher. Students studying mathematics in secondary schools in Ado Local Government Area, Ekiti State, Nigeria, made up the study population. The sample consisted of two intact classes of senior secondary school two (SS II) mathematics students from each of the two nearby schools that were purposefully chosen. The selection of the schools was based on the availability of working on the computer systems. Simple random sampling divided two intact classes into experimental and control groups. At the same time, the students in the control group were exposed to the traditional method, and the students in the experimental class interacted with various GeoGebra tools. Six weeks passed during the experiment. Two tools were employed to gather the data. These are the Mathematics Attitudinal Scale (MAS) and the Student Achievement Test in Mathematics (SATM). SATM was used to administer pre-tests and post-tests to the two groups. They also received MAS before and after the exercise. Descriptive statistics were used to analyze the data that were gathered. At the 0.05 significance level, t-test statistics were used to test the research hypotheses.
RESULTS AND DISCUSSION

Results

Hypothesis one

There is no significant difference in the performance of students taught Mathematics using GeoGebra software and the students taught without using GeoGebra software. The experimental group's pre-test and post-test results were compared to test this hypothesis. A t-test statistic was computed as shown in Table 1.

**Table 1.** The t-test for the performance of the experimental group in SATM (pre-test and post-test)

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>( \bar{x} )</th>
<th>SD</th>
<th>df</th>
<th>( \alpha )-level</th>
<th>( t_{cal} )</th>
<th>( t_{tab} )</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Test</td>
<td>40</td>
<td>7.30</td>
<td>2.32</td>
<td>78</td>
<td>0.05</td>
<td>2.14</td>
<td>1.98</td>
<td>Significant</td>
</tr>
<tr>
<td>Post-Test</td>
<td>40</td>
<td>8.19</td>
<td>2.21</td>
<td>78</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1 indicates the critical value \( (t_{tab}) \) of 1.98 and the outcome of the t-test statistics on the experimental group's performance at pre-test and post-test scores \( (t_{cal}) \) of 2.14, with \( df = 78 \) and at 0.05 probability level. This leads to the rejection of the null hypothesis since \( t_{cal} \) is greater than \( t_{tab} \) \( (t_{cal} > t_{tab}) \). This suggested that there was a significant difference between the mean scores of the pretest and post-test.

Hypothesis two

Before and after the treatment, students' attitudes toward mathematics did not significantly change. Table 2 displays the results of the t-test analysis indicating whether or not students' attitudes toward mathematics are influenced by their familiarity with GeoGebra.

**Table 2.** The T-test analysis of students' attitudes about mathematics based on their GeoGebra understanding (pre- and post-treatment)

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>( \bar{x} )</th>
<th>SD</th>
<th>df</th>
<th>( \alpha )-level</th>
<th>( t_{cal} )</th>
<th>( t_{tab} )</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before</td>
<td>40</td>
<td>46.61</td>
<td>6.05</td>
<td>78</td>
<td>0.05</td>
<td>2.11</td>
<td>1.98</td>
<td>Significant</td>
</tr>
<tr>
<td>After</td>
<td>40</td>
<td>49.15</td>
<td>6.42</td>
<td>78</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

According to Table 2, the computed value of 2.11 is higher than the 1.98 table value \( (2.11 > 0.98) \). This leads to rejecting the null hypothesis, which claimed no significant difference between students' attitudes toward mathematics before and after the intervention. Based on an analysis of their MAS responses before and after the treatment, it became clear that students' attitudes toward mathematics were positively impacted by their understanding towards GeoGebra.

Discussion

The study's conclusions showed that there is a statistically significant difference between the mean scores of the pre-test and post-test. The result of the study agrees with Kim & Md-Ali, (2017) and Vinerean et al. (2022) who looked into geogebra to implement 21st-century learning in Malaysian mathematics classrooms and discovered that the mean score on the post-test is substantially higher than the mean score on the pretest. Therefore, by using the GeoGebra software to learn geometry facts, figures, shapes, and space, students were able to produce work that revealed vital, innovative, and inventive elements in their solution.

The study also reveals that based on the analysis of their responses to MAS before and after the treatment, students' attitudes toward mathematics were positively influenced by their knowledge of algebra. This finding corresponds with the findings of Yorganci (2018) and Yohannes & Chen (2021) who studied the views of graduate students on the use of GeoGebra in mathematics teaching and reported that the attitude of students toward the learning of mathematics using geogebra tools was positive. Thus, attitudes significantly influenced students positively when taught mathematics using GeoGebra software.
CONCLUSION
This study investigated how senior secondary schools in Ado Ekiti, Ekiti State, Nigeria, were incorporating Geogebra software into their mathematics instruction. According to the study, there was a significant difference between the mean scores of the pre-test and post-test. Also, the results showed that students' attitudes toward mathematics were positively impacted by their knowledge of algebra. The results suggest that using geometry as a teaching and learning tool in the classroom can help students perform better. Geogebra can make useful contributions to mathematics education, demonstrating the viability of using computer-based classroom activities in teaching-learning settings. Secondly, Geometric facts, figures, shapes and their properties with actual conditions of construction were observed by using the GeoGebra. Thus, the students have the chance to verify the condition by observing the geometric properties of shapes with sufficient conditions.

REFERENCES
Feerick, E., Clerkin, A., & Cosgrove, J. (2022). Teachers’ understanding of the concept of


Integration of Geogebra Software Into Mathematics Instruction

Author(s):
*Olajumoke Olayemi Salami
Department of Science and Technology Education, Faculty of Education,
University of Johannesburg, South Africa
Email: olajumokesalami1@gmail.com

Erica Dorethea Spangenberg
Department of Science and Technology Education, Faculty of Education,
University of Johannesburg, South Africa
Email: ericas@uj.ac.za