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GEOGEBRA AND THE REMEDIATION OF DEVELOPMENTAL DYSCALCULIA TO ENHANCE THE PERFORMANCE OF LEARNERS IN STATISTICS

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Abstract
This study explored how well junior secondary students with Developmental Dyscalculia (DD) performed on basic statistics when taught using the Geogebra-Supplemented Discussion (GSD) approach. A quasi-experimental pre-post control group design was used. Thirty-eight (38) students made up the sample, 21 of whom were in the experimental group and 17 were in the control group. The diagnosis of DD among students was established using three criteria: Dyscalculia Diagnostic Test (DDT), the Previous Test Score (PTS) and the Mathematics Teacher Judgment (MTJ). The Statistics Performance Test (SPT) was used to quantify student performance in basic statistics before and after treatment. The reliability indices of SPT and DDT were established using the test-retest method to obtain 0.86 and 0.92 respectively. Descriptive statistics and ANCOVA were used to analyse the data. The results showed that the GeoGebra-Supplemented instruction was more effective than the deductive method, especially, for students with DD. Additionally, the study found that GSD is gender-friendly unlike traditional instruction, as no significant difference was found in the performance of the students with DD who received treatment using the GSD. The study recommended among others that GeoGebra be integrated into the classrooms to enhance student performance in mathematics.

Keywords: GeoGebra, Remediation, Developmental Dyscalculia, Learners, Performance, Statistics

Introduction

Technology is a powerful resource that a teacher needs when planning work for students in mathematics instruction. Technology is the application of devices, machinery, methods, crafts, systems, and organisational structures to carry out a particular task. Technology promotes effective teaching and learning by giving teachers and students a way to actively participate in the process at all levels. Learning is ideal when teachers can utilize tools that support motivation, engagement and self-efficacy to provide challenges of appropriate level and complexity. This simply suggests that a country may scarcely make noteworthy advancements without technology, which has its roots in science and mathematics. Since mathematics has come to be seen as the key to meeting daily needs, it plays a crucial role in any country's advancement in both science and technology. Without a doubt, the role of mathematics in society has demonstrated its importance as a barometer of civilisation that has conditioned everyone who aspires to a degree in science, technology, or any other subject of study.

Mathematics is a subject that has been defined by various authorities. According to Odili (2019), mathematics is the science of quantity and space. Elaine (2013) defines mathematics as the science that deals with the logic of shape, quantity and arrangement. Elaine continued by stating that mathematics is a fundamental component of everything in our everyday lives, including technology, architecture, the arts, finance, engineering, and even sports, and that it is present everywhere we look and in everything we do. By extension, mathematics is a method of logical reasoning that seeks to resolve individual and societal issues. It has benefited the human ability to communicate, live together, produce goods, and engage in leisure activities. According to the many definitions, one of mathematics' main characteristics is that it is an abstraction-heavy field. Due to the misconceptions around

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it, many students also hate studying it (Buckley, 2013, Taylor, 2010; quoted in George, 2016). Many learners, according to Glenda and Walshaw (2009), struggle with mathematics, which negatively affects their performance in examinations. Numerous factors have contributed to the consistently poor mathematics performance of students. The majority of mathematics instructions in schools today are in textbooks that focus primarily on manipulating symbols and are all too frequently opposed to children's daily lives. Other causes of unfavourable attitudes towards mathematics include endless repetition, pointless memorization, and a general lack of interest. The parents of the learners are also unable to buy books and other study resources; this contributes to the students' poor mathematics performance. In addition, some of the students find it difficult to understand some mathematics concepts due to Mathematics Learning Disabilities (MLDs).

One of the many types of Learning Difficulties (LDs) displayed by students is MLD. Mathematics-Learning Difficulties, according to Black (2003), is a mathematical disease that makes it difficult for learners to acquire mathematical concepts. MLD is described by Diane (2007) as an unexpected issue with learning mathematics when a teacher or other trained professional has given a pupil appropriate learning opportunities over time. Dyscalculia is one of the MLDs. A mathematical disability known as dyscalculia causes students to have difficulty acquiring numerical concepts. Numerical, manipulative, cognitive, reasoning, process, computational, creative, and basic mathematics operational skills impairments affect students who have trouble studying mathematics. Students may have MLD for several reasons, according to George (2018), including dyslexia, dyscalculia, cognitive delay, inadequate preparation in prerequisite skills, a delay in the development of mathematics fundamentals, and improper learning experiences. This study focuses on a particular aspect of the MLDs known as Developmental Dyscalculia (DD).

According to Akinoso (2014), the majority of students with MLDs experience difficulties due to insufficient preparation and deficient early instruction in the fundamental mathematical concepts and operations necessary for mathematics courses at their current level. According to Pandit (2000), students with MLD struggle with mathematics, although their overall mental ability test results indicate typical or above-average intellectual functioning. Their potential and actual success differ significantly, even though they have good hearing and vision, no history of chronic illness, and regular attendance in class. Diane (2007) and Paula (2012) attributed MLDs to deficiencies in one or more of the following skill types: insufficient command of number facts, computational weakness, difficulty applying knowledge and making connections, insufficient comprehension of the mathematical language, and difficulty understanding the visual and spatial aspects of mathematics. Studies in mathematics education have utilized varying methods to diagnose and remediate MLDs (Wonu & Zalmon, 2017; Wonu & Paul-Worika, 2019; Wonu, 2020; Osiagor et al., 2021; Wonu, & Nwoko, 2022). To remediate developmental dyscalculia and enhance student performance in everyday statistics there is a need to introduce technology into the classroom and GeoGebra was the technology used in this study.

Due to its many benefits, GeoGebra was adopted in this study. Since GeoGebra is free software that can be downloaded from the internet and used to teach geometry, trigonometry, calculus, algebra, and statistics, it is especially appealing to teachers on a small budget. Both in the classroom and at home, GeoGebra can be used to promote active, problem-based learning as well as mathematical experiments and discoveries (Kumah & Wonu, 2020). Points, vectors, segments, lines, polygons, conic sections, inequalities, implicit polynomials, and dynamically editable functions can all be used to create constructions. Elements can be added and changed with an input bar, mouse, and touch controls. GeoGebra includes a comprehensive set of commands, including root and extremum, and can hold variables for numbers, vectors, points, calculus derivatives, and function integration. The purpose of this study is to determine whether GeoGebra can help junior secondary students who have developmental dyscalculia improve their academic performance in basic statistics. Furthermore, it has taken several actions to make mathematics teaching and learning at the school levels activity-based and experimentation-oriented, taking into account the national aspirations and expectations reflected in the recommendations of the National Curriculum Framework (NCF). Moreover, approaches used in teaching mathematics in recent times are different from the dogmatic way of teaching it before. These help in removing the abstractness of mathematics, thereby making it more interesting for students to learn. Scholars have proposed a plethora of learning theories to support the teaching and learning of mathematics. This study is anchored on

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Seymour Papert's constructionism; which is psychological epistemology, that argues that learners develop meanings and mental models from the actual development of sharable physical objects/artefacts or projects.

Statement of the Problem

Learners in different areas of learning dread mathematics due to myths that surround it, making it difficult to comprehend. In addition, in the teaching and learning of statistics, learners with MLDs always find it very difficult to solve problems on measures of central tendency, measures of dispersion and probability because they lack the cognitive and process abilities in the understanding of the concept and therefore, cannot execute calculations. Poor performance of students in mathematics is attributed to inadequate qualified teachers, insufficient instructional materials, poor use of instructional materials and improper methods of teaching among others. The teachers' overreliance on the use of traditional methods of teaching has contributed to ineffective instructions and poor performance among students. However, research has shown that the integration of computers to encourage the use of GeoGebra can help in teaching mathematics and enhancing students' motivation, engagement and performance in the subject. In this regard, the study sought to explore the efficacy of GeoGebra as a supplemental strategy in advancing the statistics performance of junior secondary students with DD in the Obio/Akpor Local Government Area of Rivers State, Nigeria.

Aim and Objectives of the Study

The study aimed to determine the effectiveness of the GeoGebra-supplemented discussion model in advancing the everyday statistics performance of learners with developmental dyscalculia. Specifically, the objectives of the study are to:

1. determine the difference in the learning performance between students with DD who were taught everyday statistics using the GeoGebra-supplemented discussion model and those taught using the deductive teaching method
2. determine the difference in the learning performance between the male and female students with DD who studied everyday statistics with the GeoGebra-supplemented discussion model

Research Questions

1. What is the difference in the learning performance between students with DD who were taught everyday statistics using the GeoGebra-supplemented discussion model and those taught using the deductive teaching method?
2. What is the difference in the learning performance between the male and female students with DD who studied everyday statistics with the GeoGebra-supplemented discussion model?

Hypotheses

H_{03}: There is no significant difference in the learning performance between students with DD who were taught everyday statistics using the GeoGebra-supplemented discussion model and those taught using the deductive teaching method.

H_{04}: There is no significant difference in the learning performance between the male and female students with DD who studied everyday statistics with the GeoGebra-supplemented discussion model

Methodology

A quasi-experimental pretest-posttest control group research design was adopted for the investigation. The design was used because intact groups of participants were involved (Wiersma, 2000). The Junior Secondary School Two (JSS2) students participated in the study since they had to learn the fundamentals of probability and statistics. There were 38 JSS2 students in the sample for this study. Two out of the fifteen schools were randomly chosen, and two intact classes were chosen from the sampled schools using the purposive sampling method. The researchers considered a school with an adequate supply of computers. Three criteria-the Dyscalculia Diagnostic Test (DDT), the Previous Test Score (PTS), and the Mathematics Teacher Judgement (MTJ)-were used to diagnose dyscalculic students in JSS2. Since reviews suggested that teacher judgements were reliable assessments of students' achievement-related behaviours, teacher judgements were applied (Winne & Perry, 2000). These standards could appear to be highly specific guidelines for identifying whether a particular learner falls inside the

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umbrella of pupils with DD in mathematics. The experimental group consisted of 21 students with DD (8 males and 13 females), while the control group consisted of 17 students with DD (10 males and 7 females).

The Statistics Performance Test (SPT) gathered data on how the students with DD performed on basic statistics tests. There were 25 multiple-choice statistics questions with four possible answers (A-D), only one of which was the right answer. The decision on how to create the SPT using the table of specifications was influenced by the total number of items for each topic, process objectives based on the relative relevance of the topics, and the time spent teaching the topics. Experts in Mathematics Education validated the instruments. The reliability indices of the instruments were established using the test-retest method to obtain 0.86 for SPT and 0.92 for DDT respectively. The two groups of students were pre-tested before the treatment to confirm that they were all equal in terms of entry behaviour. Before commencing to teach mathematics, the instructors were trained by the researchers in GeoGebra augmented instructional model and a deductive method. The original instructors in the classes implemented the instructions in each group. The researchers monitored the instructors to make sure they did not break from the lesson plan throughout the teaching session. Teachers in both the experimental and control groups were heavily reliant on the lesson plans for direction. The experimental group received treatment using GeoGebra augmented discussion model whereas the control group was taught using deductive instruction. In the experimental group, the strategic components of the discussion model were used to present the introductions, the teacher monitored the problem-solving process and integrated the knowledge into the lesson. After the treatments, the two groups were also tested to find out how well they performed. Statistics Performance Test was used for the pretest and post-test to measure the everyday statistics performance of students with DD. The mean and standard deviation were used to answer the research questions, while Analysis of Covariance (ANCOVA) was used to test the research hypotheses at a 0.05 level of significance.

Results

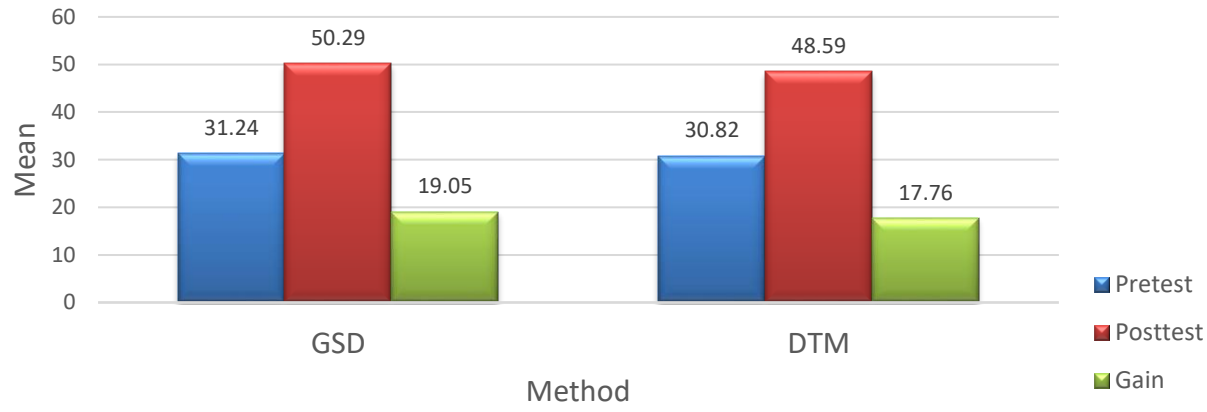

Fig. 1: Variation in the mean scores of learners with DD taught using GSD and those taught with DTM

Figure 1 and Table 1 (appendices) show that the pretest mean score of students with DD taught using the GSD was 31.24, SD=4.67 whereas their posttest mean score was 50.29, SD=3.18 and their mean learning gain score was 19.05, SD=2.25. The pretest mean score of the students with DD taught everyday statistics using the DTM was 30.82, SD=4.30 whereas their posttest mean score was 48.59, SD=2.32 and their mean learning gain score was 17.76, SD=2.63.

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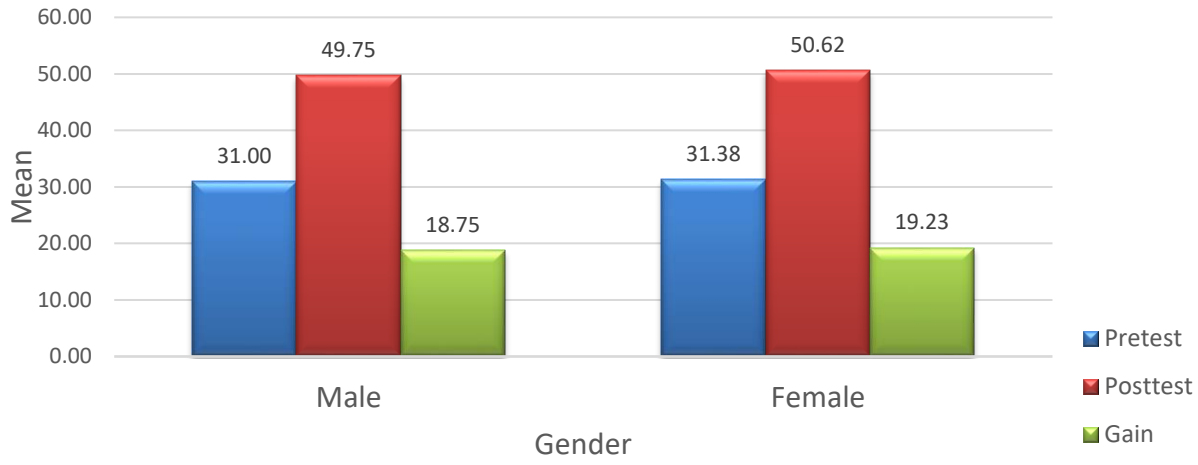

Fig. 2: Variation in the mean scores of learners with DD taught using GSD based on gender

The learning performance differences between male and female students with developmental dyscalculia who studied basic statistics with a discussion model supplemented by GeoGebra are summarised in Figure 2 and Table 2 (appendices). It shows that the pretest mean score of male students with DD who studied everyday statistics with the GSD model was 31.00, SD=6.23; whereas their posttest mean score was 49.75, SD=4.06 and their mean learning gain score was 18.75, SD=2.82. The pretest mean score of female students with DD who studied everyday statistics with the GSD model was 31.38, SD=3.69whereas their posttest mean score was 50.62, SD=2.63 and their mean earning gain score was 19.23, SD=1.92.

Table 3 Summary of ANCOVA on the difference in the learning performance between the students with DD who studied everyday statistics with the GSD model and those who studied the same topic using the DTM

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	250.329[a]	2	125.164	67.246	.000	.794
Intercept	777.813	1	777.813	417.891	.000	.923
Pretest	223.258	1	223.258	119.949	.000	.774
Treatment	20.217	1	20.217	10.862	.002	.237
Error	65.145	35	1.861			
Total	93524.000	38				
Corrected Total	315.474	37				

a. R Squared = .941 (Adjusted R Squared = .938)

The results of the ANCOVA are summarised in Table 3, which compares the learning outcomes of students with DD who learned common statistics using the GSD model versus those who did so using the deductive teaching approach. The study's findings demonstrate a significant difference in learning outcomes between students with DD who studied basic statistics using a discussion model supplemented by GeoGebra and those who used the deductive teaching approach ($F1, 35=10.862$, $p=0.002$, $\eta^2=0.237$) at 0.05 level of significance resulted in the null hypothesis one being rejected.

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Table 4: Summary of ANCOVA on the difference in the learning performance between the male and female students with DD who studied everyday statistics with GeoGebra supplemented discussion model

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	167.468[b]	2	83.734	43.289	.000	.828
Intercept	421.490	1	421.490	217.902	.000	.924
Pretest	163.759	1	163.759	84.660	.000	.825
Gender	1.959	1	1.959	1.013	.328	.053
Error	34.818	18	1.934			
Total	53304.000	21				
Corrected Total	202.286	20				

The summary of the ANCOVA on the learning performance differences between the male and female students with developmental dyscalculia who studied common statistics with a discussion model supplemented by GeoGebra is shown in Table 4. The findings indicate that there was no discernible difference in the learning outcomes between the developmental dyscalculic male and female students who learned common statistics using a conversation format that was supplemented with GeoGebra. ($F1,18=1.013$, $p=0.328$, $\eta 2=0.053$). At 0.05 levels of significance, null hypothesis number one was retained.

Discussion of the findings

The findings from Table 1 (Figure 1) revealed that the experimental group who studied everyday statistics with the GSD model performed higher than the control group -those who studied the same topic using the DTM method. When put to the statistical test using ANCOVA, the findings from Table 3 revealed that there is a significant difference in the performance mean score between students with DD who were taught everyday statistics with the GSD model and those taught the same topic using the deductive teaching method (DTM). These results are consistent with those of Oti and George (2020), who found that students with dyscalculia performed better on trigonometry tests while using the GeoGebra software package than when using the deductive teaching approach. The results of the current study thus provide more evidence for the GSD model's effectiveness in delivering mathematics teaching in educational settings.

The finding from Table 2 (Figure 2) showed that the mean difference in the learning gain between the male and female students with DD who studied everyday statistics with the GSD model showed that the males have a mean of 18.75 whereas the females had a mean of 19.23. The study demonstrates that the GSP model has a stronger effect on the performance of female students in commonplace statistics. The results from Table 4 indicated that there is no statistically significant difference in their mean performance when put to the test using ANCOVA. This is corroborated by Woji's findings in the year 2021, which showed that female students had higher mean score advances in trigonometry performance than their male counterparts did. Though the GSD model was used to teach students with developmental dyscalculia (DD) everyday statistics, the results of the hypothesis did not find any statistically significant differences between male and female students in terms of their performance means scores.

Conclusion

The study aimed to determine the effectiveness of GSD mode in advancing the everyday statistics performance of learners with DD. The study established that the GSD could be used to improve the statistics performance of students with DD. It can promote learning outcomes better than the deductive method of instruction. The package aided junior secondary students with DD who find it difficult to solve mathematical problems involving calculations to improve learning. GeoGebra is an interactive programme for teaching geometry, algebra, statistics, and calculus applications in mathematics and science Integrating GeoGebra into the classrooms will have positive implications for student learning outcomes. Therefore, GeoGebra should be used by math teachers to assist their students in learning statistics. The results of this study showed that GeoGebra-supplemented education, in contrast to traditional instruction, is gender-friendly, and as a result, it should be used in the teaching of mathematics to improve student performance in the subject.

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Recommendations

In line with the findings of this study, the researcher made the following recommendations:

1. Mathematics and statistics teachers should adopt GeoGebra-supplemented instruction in their instructional delivery to ensure better instructional outcomes and gender-friendly classrooms.
2. Government should equip schools with computers to ensure the use of the GeoGebra-supplemented instruction by mathematics and statistics teachers.

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Appendices

Table 1: Summary of descriptive statistics on the difference in the performance between the students with DD who studied everyday statistics with GSD model and those who studied the same topic using the DTM

		Pretest		Posttest		Gain	
Group	**N**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
GSD	21	31.24	4.67	50.29	3.18	19.05	2.25
DTM	17	30.82	4.30	48.59	2.32	17.76	2.63

Table 2: Summary of descriptive statistics on the difference in the learning performance between the male and female students with DD who studied everyday statistics with GSD

			Pretest		Posttest		Gain	
Group	**Gender**	**N**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
GSD	Male	8	31.00	6.23	49.75	4.06	18.75	2.82
	Female	13	31.38	3.69	50.62	2.63	19.23	1.92

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