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DISCOVERY LEARNING MODEL AND THE REMEDIATION OF DEVELOPMENTAL DYSCALCULIA IN NUMBER AND NUMERATION

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Abstract
The goal of the study was to use the Discovery Learning Model (DLM) as an educational intervention to improve the performance of junior secondary students in the Port Harcourt Local Government Area (LGA) who have developmental dyscalculia (DD) in Number and Numeration (NAN). The study's design was a quasi-experimental one. Participating in the study were 73 Junior Secondary Class 2 (JSC2) students with DD in NAN. Two junior secondary schools that were chosen at random were included. The control group was randomly assigned to one school, while the experimental group was assigned to the other. Three criteria were included in the diagnosis, identification, and selection of students with DD for the study: computing the median score of prior academic performance; administering the Developmental Dyscalculia Diagnostic Test (3DT); and teacher evaluations. Data were gathered using the Number and Numeracy Performance Test (NANPT) and 3DT. While the 3DT was meant to diagnose and identify learners with DD before the intervention, the NANPT was used to quantify student performance in NAN. The Kuder-Richardson, KR-21 formula was used to calculate the reliability indices, which resulted in indices of 0.87 and 0.84 for NANPT and 3DT, respectively. While students in the control group were taught the identical contents through the traditional teaching method (TTM), those in the experimental group learned using the DLM. The study was guided by two research questions and two hypotheses. Data analysis methods included the mean, standard deviation, and Analysis of Covariance (ANCOVA). The results showed that the DLM advanced the performance of students with DD in NAN better than the TTM. Based on gender, there was no significant difference in the students' NAN performance using DLM. It was recommended, among others, that mathematics teachers use DLM in their classroom lessons and make sure that all students actively participate to improve student-learning outcomes.

Keywords: Discovery Learning Model**,** Gender, Mathematics, Junior Secondary, Developmental dyscalculia

Introduction

The Discovery Learning Model (DLM) is an approach to education that emphasizes student exploration and experimentation to learn new concepts and skills. It is predicated on the idea that participation in the learning process rather than passively absorbing knowledge from a teacher or textbook results in better learning for learners. Students are encouraged to pose questions, develop hypotheses, and plan experiments or other activities to test their theories in the DLM. Teachers that help them as facilitators rather than lecturers allow them the flexibility to explore and learn new material and concepts at their speed. The DLM is often used in science and mathematics education, where students are allowed to work with materials and tools to explore scientific and mathematical concepts. It can also be used in other subjects, such as social studies and language arts, where students are encouraged to conduct research and engage in creative problem-solving. The DLM is also known as inquiry-based learning or constructivist learning. It is based on the theories of cognitive psychology, which emphasize the importance of active participation and self-directed learning in the acquisition of knowledge and skills. In the DLM, students are encouraged to explore and discover new knowledge through their inquiry and investigation. This process is often facilitated by the teacher, who provides guidance and support while allowing

students to take ownership of their learning. The teacher helps students to identify their own learning goals and provides resources and tools to help them achieve those goals. One of the key principles of the DLM is that learning is most effective when it is relevant and meaningful to the learner. This means that students are more likely to remember and apply what they have learned when they have a personal interest in the topic. The DLM also emphasizes the importance of reflection and feedback, as students are encouraged to reflect on their learning and receive feedback from their peers and teacher to improve their understanding. Some of the benefits of the DLM include increased student engagement and motivation, improved critical thinking and problem-solving skills, and a deeper understanding of concepts. However, it can also be challenging for students who are accustomed to more structured and teacher-directed approaches to learning and may require more scaffolding and support from the teacher.

The DLM is anchored on the constructivist theory, which upholds and has given rise to self-guided pedagogical approaches, whose effectiveness has been widely acknowledged (Alferi et al., 2011). In 1961, Bruner proposed DLM. An educational strategy known as "discovery learning" places a strong emphasis on the student's participation in the learning process. It is predicated on the assumption that students learn best when they actively participate in the process of independently learning new knowledge and concepts. Discovery Learning is a process whereby concepts, meanings, and relationships are finally understood by an intuitive process (Mendikbud, 2013). When a person is involved, especially when using mental processes to uncover some of the concepts and principles, discovery happens. Through observation, categorization, measurement, prediction, determination, and inference, knowledge is discovered. The method is cognitive, whereas the discovery process itself is a mental activity that involves the assimilation of ideas and principles (Mendikbud, 2013). By experimenting with a domain and deducing rules from the outcomes of these trials, learners build their knowledge via the discovery learning approach, according to Balim (2009). The fundamental tenet of this kind of method is that learners are building their knowledge because they may plan their experiments in the domain and infer the laws of the domain for themselves. It is expected that they will comprehend the subject at a deeper level as a result of these creative activities than when the relevant knowledge is simply delivered by a teacher or in an expository learning setting.

There is a growing body of research on the use of the DLM in the teaching of numeracy. The current literature suggests that DLM is an effective instructional approach for teaching numeracy, particularly in the areas of problem-solving and conceptual understanding. However, further research is needed to explore the effectiveness of DLM in different contexts and with different student populations. Chen et al. (2018) conducted a meta-analysis of 29 studies on the use of DLM in the teaching of mathematics. They found that DLM was effective in improving student achievement, particularly in the areas of problem-solving and conceptual understanding. Zhang et al. (2020) also conducted a randomized controlled trial comparing the effectiveness of DLM with traditional instruction in a Chinese primary school. They found that students who received DLM instruction showed greater gains in problem-solving and conceptual understanding than those who received traditional instruction. Wang et al. (2021) also conducted a study on the use of DLM in the teaching of fractions to elementary school students in China. They found that this method was effective in improving students' understanding of fraction concepts and their ability to solve fraction problems. Kashefi et al. (2021) explored the effectiveness of DLM in teaching basic mathematics skills to students with intellectual disabilities. The results showed that DLM was effective in improving students' mathematical performance, and the authors suggest that DLM can be an effective approach for teaching mathematics to students with disabilities. Similarly, Adhikari et al. (2021) explored the use of DLM in teaching mathematics to Nepalese primary school students. They found that DLM was effective in improving students' mathematical skills and problem-solving abilities. Jiang et al. (2020) conducted a study on the use of DLM in teaching statistics to Chinese college students. The results showed that DLM was effective in improving students' statistical knowledge and critical thinking skills. Nguyen et al. (2021) explored the use of DLM in teaching fractions to Vietnamese middle school students.

The impact of discovery learning on students' achievement and inquiry-based learning abilities was examined by Balim (2009). He looked at fifty-seven third-graders from an elementary public school in Izmir, Turkey's third-largest city, with a middle-class economic profile (30 boys and 27 girls). 29 students made up the control group, while 28 students were in the experimental group. It used a pre-test and post-test quasi-experimental research design. According to the study's findings, the experimental group outperformed the control group on average in

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terms of academic accomplishment, scores on learning retention, and perceptions of inquiry learning skills on both cognitive and affective levels. To understand how students make interactive models relevant for use as resources in scientific discovery and how interactive models can be designed to stimulate discovery. Butterworth et al. (2011) looked into interaction design and science discovery learning in the future classroom. The analysis's findings indicate that for students to use models as sources, they need time to explore them. Hanafi (2016) looked into how the DLM application affected students' social attitudes and listening outcomes. The study found that using the discovery learning model significantly improved the learning outcomes for the attitude aspect. The results showed that DLM was effective in improving students' understanding of fraction concepts and their ability to solve fraction problems. In the same vein, Suratno et al. (2019) explored how discovery learning affects students who have strong mathematics communication skills. It demonstrated the clear efficacy of the discovery learning approach for solving mathematical problems. The study also showed that 80% of the pupils had a level of skill in problem-solving. Through the use of guided discovery, children can learn about the idea of discovery. The constructivist approach includes a crucial element called learning with discovery, in which students gain new insights into the experiences they have and connect them to their prior knowledge. This is outstanding and can be upheld without a doubt that distinction comes when the discovery learning method is used appropriately. These studies suggest that DLM can be an effective instructional approach for teaching mathematics to a variety of student populations, including students with dyscalculia and students in different cultural contexts.

Dyscalculia is a learning disability that affects an individual's ability to understand and perform mathematical calculations. According to a systematic review and meta-analysis by Peng et al. (2016), the global prevalence of dyscalculia is estimated to be between 3% and 6%, although the prevalence rates varied across studies and populations. A meta-analysis by Fias et al. (2013) found that dyscalculia is more prevalent in boys than girls, with a male-to-female ratio of 1.6:1. A systematic review by Mazzocco et al. (2011) found that some studies report a male-to-female ratio of up to 3:1 for dyscalculia. Dyscalculia is often comorbid with other learning disabilities, such as dyslexia and ADHD (Willcutt et al., 2013). A longitudinal study by Geary et al. (2013) found that mathematics ability in childhood predicts mathematics performance in adulthood and is strongly related to educational and career outcomes. In light of the fact that mathematics abilities are necessary for many professions, especially those in the disciplines of science, technology, engineering, and mathematics (STEM), it is implied that it may have a substantial impact on academic and professional performance. Although the precise origin of dyscalculia is not yet fully known, research indicates that it may be influenced by variations in the structure or function of the brain. Individuals with dyscalculia may have difficulty with number sense, arithmetic operations, and mathematical reasoning. Specifically, a review by Price and Ansari (2011) discusses evidence suggesting that dyscalculia may be associated with abnormalities in brain structure and function, particularly in areas involved in numerical processing and calculation.

Dyscalculia can be diagnosed through a comprehensive assessment of an individual's mathematical abilities and is often treated through targeted interventions such as tutoring or cognitive training. The International Dyslexia Association provides guidelines for the assessment and diagnosis of dyscalculia, which typically involves evaluating an individual's mathematical abilities across a range of tasks and domains. Treatment for dyscalculia typically involves a combination of accommodations, such as providing additional time on tests or using assistive technology, and interventions, such as tutoring or cognitive training. Early identification and intervention can be key to helping individuals with dyscalculia to develop effective coping strategies and achieve academic success (Butterworth et al., 2011; Wilson & Dehaene, 2007). Numerous approaches have been used in studies on mathematics education to identify and remediate MLDs (Wonu & Zalmon, 2017; Wonu & Paul-Worika, 2019; Wonu, 2020; Osiagor et al., 2021; Wonu, & Nwoko, 2022). There is a need to offer an innovative strategy like DLM to treat developmental dyscalculia and improve student performance in mathematics. It is seemingly interesting to note at this point that, as effective as this teaching method, further revelation needs to be put to light on the use of DLM to remediate developmental dyscalculia amongst students in Port Harcourt LGA of Rivers State.

Statement of the problem

Dyscalculia is a specific learning disability (SLD) that affects a person's ability to understand and perform mathematical concepts and operations involving numeracy. There are several reasons why dyscalculics may have

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difficulty with mathematics: difficulty with number sense, difficulty with arithmetic operations, difficulty with spatial reasoning, difficulty with working memory, and anxiety or stress. All these factors contribute to their poor performance in NAN. It is worthy of note that dyscalculia is not related to intelligence, and dyscalculics can excel in other areas. Mathematics educators have recognized the unique needs of DD and have developed strategies to improve their learning outcomes. Some of these strategies include multi-sensory teaching, explicit instruction, individualized instruction, and the use of technology, building mathematics confidence, and collaboration with other professionals. By providing individualized support and a supportive learning environment, dyscalculics can develop the skills and confidence they need to succeed in mathematics. Teaching and learning is an activity that is bound to be a recurring event in the educational sector and without disputation, problems will surface for solutions to be initiated and implemented. A lot of researchers and scholars are on the go rendering as many solutions as possible and thence getting headway for encountered problems in the classroom. To contribute to this scholarly movement this study was initiated, hence a look into the effect of DLM on the performance of students with DD, taught NAN is the overarching goal of this study.

Aim and Objectives of the Study

The study aims to investigate the effectiveness of the DLM in advancing the performance of students with DD in NAN in Port Harcourt LGA. Specifically, the objectives of the study are to:

1. investigate the effect of DLM on the performance of students with DD in NAN
2. determine the influence of gender on the performance of students with DD taught using DLM in NAN

Research questions

The following research questions guided the study:

1. What is the mean difference in the performance of students with DD taught NAN using DLM and those taught the same topics using the TTM?
2. What is the difference in the performance mean scores between the male and the female students with DD taught NAN using the DLM?

Hypotheses

The following null hypotheses were tested at a 0.05 level of significance to guide the study:

H_{01}: There is no significant difference in the performance of students with DD taught NAN using DLM and those taught the same topics using the TTM.

H_{02}: There is no significant difference in the performance mean scores between male and female students with DD taught NAN using the DLM.

Materials and Methods

This study adopted the quasi-experimental design. It was used to determine the effectiveness of the DLM in enhancing the performance of JSC2 students with DD, taught NAN. The sample for the study is 73 dyscalculic JSC2 students. Two secondary schools were randomly selected from the Port Harcourt LGA. One school was randomly assigned to the experimental group while the second school was assigned to the control group. The instruments for data collection were of two categories namely the Developmental Dyscalculic Diagnostic Test (3DT) and the Number and Numeration Performance Test (NANPT) respectively. The 3DT was used to diagnose and identify the dyscalculic students while the NANPT is used for both the pre-test and post-test measures of student performance in NAN. In consideration of the reliability test, Kuder-Richardson, KR-21 was used to ascertain the reliability of the instruments, which gave indices of 0.87 and 0.84 for NANPT and 3DT respectively. Firstly, a letter of introduction was sent to the principals of the schools to seek approval for involving the JSC2 students in the study. Upon approval, the researchers guided the teachers in administering the tests and treatment accordingly, after receiving orientations on the theoretical and practical applications of DLM. The implementation of the DLM in NAN typically involves several classroom procedures, which varied depending on the specific curriculum and the needs of the students. In this case, summarily, the following procedures were adopted: introducing the concept, hands-on exploration, guided inquiry, collaborative learning, reflection and assessment, and differentiation. The data collected were analyzed with mean and standard deviation to answer the research questions and Analysis of Covariance (ANCOVA) was used to test the hypotheses at a 95% confidence interval.

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Results

Table 1: Summary of descriptive statistics and ANCOVA on the differences in the performance of JSC2 students with DD in NAN taught using the DLM and those taught using the TTM

Method		Pretest		Posttest		Gain	
	N	Mean	SD	Mean	SD	Mean	SD
DLM	38	33.26	10.19	56.74	11.15	23.47	14.47
TTM	35	32.00	8.68	47.31	13.03	15.31	10.69
	F1, 70 =10.79, p = .002, η^2= .134						

The data in Table 1 above revealed the descriptive statistics and ANCOVA on the difference between the performance of JSC2 students with DD in NAN taught using the DLM and those taught using the TTM. It revealed that the pretest mean of the students taught with the DLM had a performance mean score of 33.26, SD=10.19 and a posttest performance mean score of 56.74, SD=11.15 and a mean gain of 23.47, SD=14.47. In consideration of those taught with TTM, the pretest revealed a mean of 32.00, SD=8.68 but their posttest performance was 47.31, SD=13.03 and a mean gain of 15.31, SD=10.69.

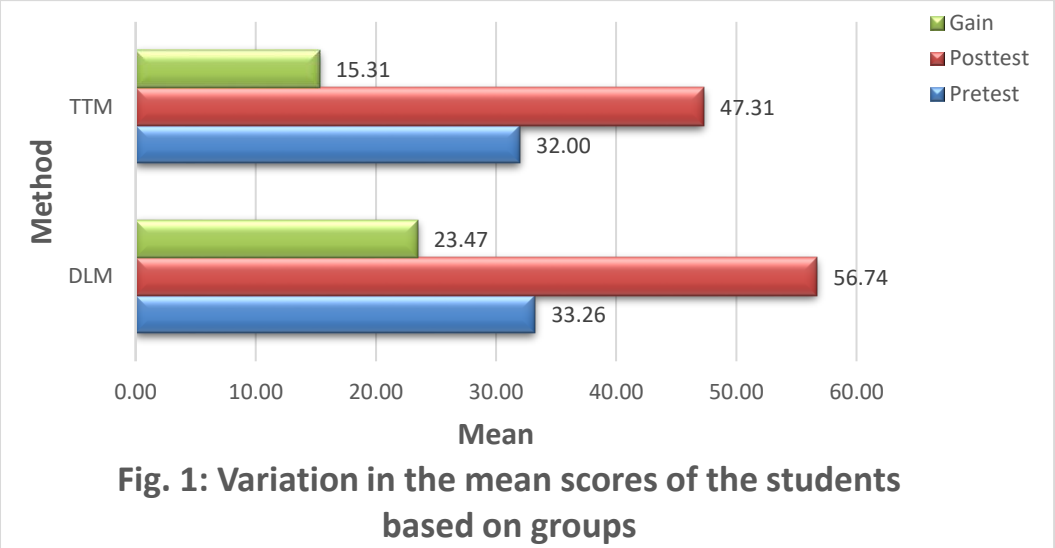

Fig. 1: Variation in the mean scores of the students based on groups

The inferential analysis of ANCOVA showed that there is a significant difference between the performance of junior secondary students with developmental dyscalculia in number and numeration taught using the DLM and those taught using the TTM ($F_{1,70}$=10.79, p=.002). Meaning that, null hypothesis two is rejected while the alternative hypothesis is retained at a 0.05 level of significance. The Partial Eta Square, η^2 =0.134, which according to Cohen's proposal is a low effect. This account for a 13.4% variation.

Table 2: Summary of descriptive statistics and ANCOVA on the performance of the male and female junior secondary students with DD taught using DLM

Gender		Pretest		Posttest		Gain	
	N	Mean	SD	Mean	SD	Mean	SD
Male	21	32.19	10.24	55.81	10.77	23.62	14.02
Female	17	34.59	10.29	57.88	11.84	23.29	15.44
	F1, 35 = .253, p = .618, η^2= .007						

The data in Table 2 above revealed the descriptive statistics and ANCOVA on the difference between the male and female junior secondary students' performance with DD in number and numeration taught using the DLM.

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Regarding the male junior secondary school students with DD taught using DLM, they had a pretest performance of 32.19, SD=10.24 while their posttest performance mean score was 55.81, SD=10.77 and a mean gain of 23.62, SD=14.02. In consideration of the female junior secondary students with DD taught using DLM, they had a pretest performance mean score of 34.59, SD=10.29 and also a post-test performance of 57.88, SD=11.84 and a mean gain of 23.29, SD=15.44.

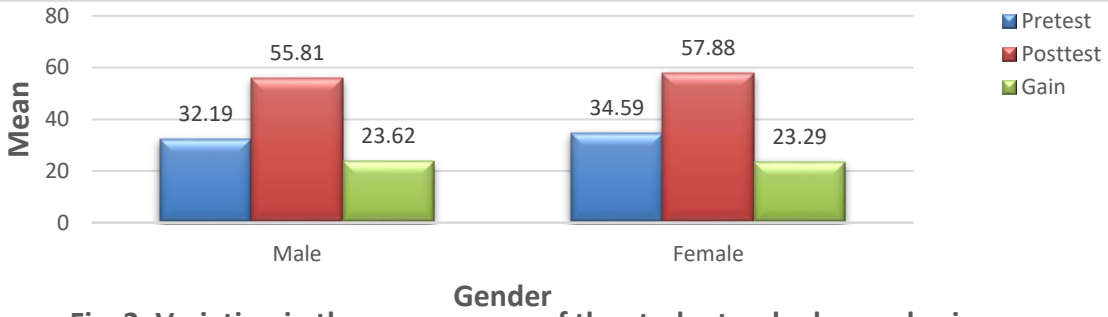

Fig. 2: Variation in the mean scores of the students who learned using DLM based on gender

The ANCOVA results showed that there is no significant difference between the performance of the male and female junior secondary students with DD taught using DLM ($F_{1,35}$ =.253, p=.618). The null hypothesis two was retained at a 0.05 level of significance. The Partial Eta Square estimated the effect size of the independent variable on the dependent variable. The Partial Eta Square, η^2= .007 which according to Cohen's proposal is low effect. This account for about 0.7% variation.

Discussion

The result provided by Table 1 showed that junior secondary students with DD taught number and numeration using the DLM performed better than those taught using the TTM. The inherent activity-based nature of the DLM group enhances students' performance in number and numeration. It exposed the students to the practical application of the concept taught. The corresponding hypothesis one showed that there is a significant difference between the performance of Junior Secondary students with developmental dyscalculia in number and numeration taught using the DLM and those taught using the TTM. Studies have shown that explicit instruction that uses a structured, systematic approach can be effective in improving the mathematics skills of dyscalculics. DLM is one such approach that emphasizes the importance of active exploration and discovery of mathematical concepts. By providing students with opportunities to engage with math in meaningful ways and make connections between different concepts, DLM can help dyscalculics develop a deeper understanding of mathematics. The study agreed with Tota (2017) who found that the critical thinking ability of students applying the DLM is better than students' critical thinking ability with conventional learning.

The result provided in Table 2 showed that female students with DD taught number and numeration using the DLM performed slightly better than their male counterparts taught with DLM. The corresponding hypothesis two showed that there is no significant difference between the performance of the male and female junior secondary students with developmental dyscalculia taught using the discovery learning method (DLM). There is limited research on gender differences in the numeracy performance of dyscalculics using the Discovery Learning Model (DLM). However, some studies have found that there may be gender differences in how dyscalculics respond to different instructional approaches. Mazzocco and Thompson (2005) found that girls with mathematics difficulties tended to have better visual-spatial skills than boys with mathematics difficulties. This may have implications for how dyscalculics respond to DLM, which emphasizes visual and spatial reasoning. Generally, while there is limited research on gender differences in the numeracy performance of dyscalculics using DLM, there is evidence to suggest that different instructional approaches may be more effective for different groups of students, including boys and girls.

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Conclusion

The findings of this study have added to the evidence which suggests that explicit instruction using DLM has a positive impact on the number and numeration performance of dyscalculics. The DLM can help dyscalculics develop a deeper understanding of mathematics. In conclusion, while there is evidence to suggest that explicit instruction using DLM can be effective for improving the mathematics performance of dyscalculics, the degree to which it can significantly impact their performance may depend on individual student characteristics, such as the severity of the dyscalculia and the age of the student. It may also depend on the specific implementation of DLM and the expertise of the teacher which were outside the scope of the study. The study also found that even though male students with developmental dyscalculia were taught NAN using the DLM performed slightly better than their female counterparts. The study however demonstrated that gender differences in the performance of students exposed to DLM did not vary significantly. In general, the study concludes that DLM enhanced student performance in NAN Also, the strategy was found to be gender friendly and free from gender bias, hence the teaching strategy is recommended as a supplemental teaching strategy to conventional teaching methods to enhance student learning and participation. In the mathematics classroom, DLM is important, as it will encourage student involvement in the teaching and learning process rather than being passive and observant alone. Hence, teachers are encouraged to integrate this teaching strategy into their classroom instructions.

Recommendations

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

1. Mathematics teachers should use DLM in their classroom lessons and make sure that all students actively participate to improve student-learning outcomes.
2. There are occasions where a particular sex student would want to rely on the other gender for assistance and solutions without effective engagement in the learning process. To this end, the teacher should ensure that guiding the students to discover learning themselves that none of the sex is depending on the other for solutions without active participation.

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