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Differential efficacy of self-regulation empowerment and scaffolding in managing dyscalculia among secondary school students

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Abstract

Mathematics learning difficulties, such as dyscalculia, continue to impede academic achievement among secondary school students, yet effective intervention strategies remain limited. Research exploring evidence-based approaches to manage dyscalculia, particularly through metacognitive and instructional supports, is still insufficient. This study investigated the effectiveness of self-regulation empowerment training and scaffolding in managing dyscalculia among public secondary school students. A quasi-experimental design with pretest, posttest, and control groups was employed, involving 67 participants selected from a larger population through multistage sampling. The Dyscalculia Screening Scale, adapted from an established screening tool, was used for data collection, with reliability confirmed before implementation. Data were analyzed using descriptive and inferential statistics. Findings indicated that students exposed to self-regulation empowerment training and scaffolding demonstrated improved mathematical performance and reduced dyscalculic tendencies compared to their peers in the control group. The study underscores the efficacy of metacognitive and scaffold-based interventions in addressing learning difficulties and enhancing self-regulated learning among students with dyscalculia. It recommends incorporating structured empowerment and scaffolding techniques into mathematics instruction to promote inclusivity and academic resilience.

Keywords: Dyscalculia; intervention strategies; scaffolding; secondary education; self-regulation.

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1. INTRODUCTION

Learning has been acknowledged as an essential process of intellectual or attitudinal change, which always gradually influences human behaviour. Multifaceted human experience as an active process has been observed to be the outcome of learning (Abu-Hamour & Al-Hmouz, 2016). The cause of learning disabilities seems to be the malfunctioning of one area or another of the brain because the brains of the disabled are wired differently from those of others. This difference affects how they receive and process information (Osisanya et al., 2018; Adi et al., 2024). Due to these reasons, some categories of individuals do not interpret correctly what their senses perceive; therefore, they do not learn the normal way other learners do. This group of learners falls under the category of learning disabilities/difficulties, and dyscalculia is one of them. The term dyscalculia is derived from the combination of Greek and Latin words: "Dys" comes from the Greek word, which means "difficulty"; "calculia" from the Latin word, which means calculation (Khing, 2016). Literally, dyscalculia means calculation difficulty. It is difficult to distinguish individuals with dyscalculia from those who are 'slow learners' (delayed acquisition), or suffering from impaired acquisition due to low cognitive ability (Butterworth, 2010). These challenges in identifying dyscalculia further contribute to the lack of its recognition. Dyscalculia is quite common among adolescents aged 11-19 years (secondary school age) (APA, 2013).

Some students have difficulties with abstract concepts of time and directions, recalling schedules and sequences of events as well as with mathematical concepts, rules, formulas, basic addition, subtraction, multiplication and division of facts (Karagiannakis et al., 2014) and indirectly contribute to a higher probability of unemployment and also causes depressive symptoms twice as high as people who do not have dyscalculia (Mahmud et al., 2020). Students with dyscalculia have little or no confidence in their ability to study numerically related subjects, with low levels of concentration, which may lead to poor performance in numeracy. The fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-V) noted that the "prevalence of specific learning disorders across the academic domains of reading, writing, and mathematics is 5-15% among school-age children" (APA, 2013). Dyscalculia has been observed to be prevalent in the United Kingdom (Snyder et al., 2016), in the United States of America (Haberstroh & Schulte-Körne, 2019), and found to be more prevalent among males (2%) than females (1.3%) (Onukwufor, 2016). However, the continued high failure rate in the internal and external school examinations is presumed to be evidence of learning difficulties at both primary and secondary school and tertiary education stages. The presumption of this might be learning disabilities: dyslexia and dyscalculia, since these disorders affect reading and mathematical skills (Westwood, 2016).

In Nigeria, the prevalence of dyscalculia disorder is said to be moderately prevalent among all public secondary school students (Igbineweka et al., 2023). However, the researchers believe that the poor performance rate in mathematics among students in National Examinations like the West African Senior Secondary School Certificate Examinations (WASSCE) and National Examination Council (NECO), as shown from 2016 to 2021, as depicted below (tables 1, 2);

Table 1

Statistics of students' performance in mathematics in the WAEC in Nigeria

Year	Number of Students who sat	No of students with A1-C6	% of students with A1-C6	No of students with D7-F9	% of students with D7-F9
2016	1,544,234	597,310	38.68	946,924	61.32
2017	1,559,162	796,041	59.22	54,8169	40.78
2018	1,572,396	786,016	49.98	786,380	50.02
2019	1,590,173	447,809	28.16	1,142,364	71.84
2020	1,538,445	425,022	27.53	1,113,423	72.37
2021	1,560,261	688,858	44.15	871,403	55.85

Table 2

Statistics of students' performance in mathematics in the NECO in Nigeria

Year	Number of Students who sat	No of students with A1-C6	% of students with A1-C6	No of students with D7-F9	% of students with D7-F9
2016	1,022,474	812,846	80.16	209,628	19.84
2017	1,051,472	745,053	70.85	306,419	29.15
2018	1,032,729	738,195	71.48	294,534	28.52
2019	1,151,016	829,787	71.59	321,229	28.41
2020	1,209,992	984,101	73.89	225,891	26.11
2021	1,225,631	945,853	77.17	279,778	22.83

When students with dyscalculia are not identified and treated, they may be labelled as lazy, not intelligent, or incompetent. These negative perceptions may affect them psychologically, as they may have been misjudged. Subsequently, they may start to believe that they may never acquire adequate numeracy skills as well as their peers or friends, which may likely make them develop an avoidance of numeracy-related subjects. Furthermore, these students may drop out of school and get involved in antisocial activities like cultism and stealing, among others, that will disrupt public peace and the safety of individuals.

Self-regulation training strategies (SRET) as an approach has evolved in the field of cognitive and social skills (the self-regulation approach); this approach can adjust and eliminate the gaps among cognitive-behavioral theories (Karbasdehi et al., 2019). Self-regulated learning skills enhance autonomy among students who direct their endeavours to learn time management, self-monitoring, and physical and social-environmental regulation processes. Interventions and inclusive education have proven to be effective in battling various learning disorders (Espinas et al., 2025; Burningham et al., 2024; Gyereh & Shukla, 2024). Self-regulation empowerment program training is effective in managing neurocognitive and social skills in students with dyscalculia, as well as being an effective school-based remedial mathematics intervention for improving motivation, strategic skills, and mathematics achievement of academically at-risk middle school students (Karbasdehi et al., 2019; Cleary et al., 2017). Self-regulation training strategies showed Cohen's *d* (0.76-0.93), indicating that 'self-regulation empowerment training' had a remarkable effect on neurocognitive and social skills in students with dyscalculia (Karbasdehi et al., 2019). Self-regulation training strategies have been efficacious in enhancing mathematics learning and achievement (Cleary et al., 2017). Self-regulation skills promote better academic execution and cognitive aptitudes in students with learning difficulties (Kaushik & Jena, 2021; Han et al., 2025).

Scaffolding suggests that learners are most likely to benefit from tasks and activities they can accomplish only with the assistance and support of more competent individuals, i.e., tasks within their zone of proximal development (Vygotsky, 1978). Scaffolding has been observed as an effective teaching approach to students' academic achievement (Onah, 2022) and an effective strategy for managing mathematics anxiety levels (Kusmaryono et al, 2020). Scaffolding Teaching Approach to Students' Academic Achievement is more effective when the students achieve better than their counterparts in other treatment groups (Onah, 2022). According to Edekor (2020), on Scaffolding Strategy and Students' Performance in Mathematics in Senior High School in Keta Municipality, Ghana, the result indicated a significant difference between students taught with the scaffolding strategy and the traditional method. Scaffolding showed an increase in student learning achievement after its application by 33.0% to 34.5% with a corresponding decrease in the level of mathematics anxiety in students by 90.4% (Kusmaryono et al, 2020). Scaffolding Strategy on the Effect of the Teaching and Learning of Mathematics indicated that the metacognitive scaffolding strategy directly affected instructional efficiency (Turmudi et al., 2019).

1.1. Purpose of study

The purpose of this study was to examine the effectiveness of self-regulation empowerment training and scaffolding as intervention strategies for managing dyscalculia among public secondary school students. Specifically, the study sought to determine whether these metacognitive and instructional approaches could

improve mathematical performance, enhance self-regulated learning, and reduce dyscalculic tendencies compared to traditional instructional methods.

The research questions are as follows:

RQ1- What is the difference in the dyscalculia pre-test mean scores of secondary school students exposed to self-regulation empowerment training and scaffolding and the Control Group?

RQ2- What is the difference in the dyscalculia post-test mean scores of secondary school students exposed to self-regulation empowerment training and scaffolding and the Control Group?

The research hypotheses are as follows:

H1- There is no significant difference in the dyscalculia pre-test means scores of secondary school students exposed to self-regulation empowerment training and scaffolding and the Control Group.

H2- There is no significant difference in the dyscalculia post-test mean scores of secondary school students exposed to self-regulation empowerment training and scaffolding and the Control Group.

2. METHOD AND MATERIALS

The researcher employed quasi-experimental research with pretest, posttest, and control, designed to investigate the efficacy of Self-Regulation Empowerment Training and Scaffolding in managing dyscalculia traits among public secondary school students. It used the 3x3x2x2x3 factorial design. Experimental group one was exposed to Self-Regulation Empowerment Training, group two was exposed to Scaffolding, and the control group was not exposed to any intervention program. All the groups were subjected to a pretest and a posttest.

2.1. Participants

1833 students in Senior Secondary School One (SSS 1) from 21 public secondary schools registered during the 2022/2023 academic session in Ika South Local Government Area of Delta State constituted the population. This is made up of 899 male students and 934 female students, as depicted in table 3 below;

Table 3

The population of secondary school students in the Ika South local government area of Delta state

ENROLLMENT FIGURE IN PUBLIC SECONDARY SCHOOLS (SSS 1-SSS 2) FOR THE 2022/2023 ACADEMIC YEAR IN IKA LOCAL GOVERNMENT AREA OF DELTA STATE

S.N	NAME OF SCHOOLS	SSS 1		SSS 2		Total
		M	F	M	F	
1	Abavo Secondary School, Abavo	0	61	0	51	112
2	Agwaewuru Secondary School, Agwaewuru	50	63	10	17	140
3	Alidinma Secondary School, Alidinma	6	8	13	14	41
4	Alihame Mixed Secondary School, Alihame	0	0	5	4	9
5	Alihagu Secondary School, Alihagu	21	26	20	21	88
6	Alisimie Secondary School, Alisimie	33	27	23	26	109
7	Dein Palace Secondary School, Agbor-Obi	101	103	98	116	418
8	EkukuAgbor Secondary School, Ekuku	26	28	29	28	111
9	Emuhu Secondary School, Emuhu	28	16	34	35	113
10	Ihi-Iyase Secondary School, Agbor-Nta	32	20	26	45	123
11	Igumbor-Otiku Secondary School, Agbor	205	193	167	177	742
12	Ime-Obi Secondary School, Agbor-Obi	80	94	61	62	297
13	Irenuma Secondary School, Abavo	54	45	29	32	160
14	Jegbefume Secondary School, Abavo	25	17	30	16	88

15	Mixed Secondary School, Abavo	47	27	27	24	125
16	Obi-Anyima Secondary School, Obi-Anyima	33	34	26	21	114
17	Ogbemudein Mixed Secondary School, Agbor	96	128	83	109	416
18	Okpe Secondary School, Abavo	36	13	30	24	103
19	Omumu Secondary School, Omumu	8	10	2	4	24
20	Oza-Nogogo Comm. Sec. School, Oza-Nogogo	16	18	20	23	77
21	Special Education Centre, Agbor	2	3	2	4	11
	Grand Total	**899**	**934**	**735**	**853**	3421

Source: Ministry of Education, Ika South Local Government Area (2023).

The study consisted of 67 participants, selected using multistage sampling techniques. Random sampling was employed to pick three co-educational schools from the twenty-one Ika South Local Government Area schools. They were labelled as schools A, B, and C, respectively. The Dyscalculia Screening Scale (DSS) was administered to all the students in SS1 of the selected schools. The benchmark score of 80 and above was obtained from students' responses to the Dyscalculia Screening Scale (DSS), and 25 students were selected from school A, 23 students were selected from school B, and 19 students were selected from school C, bringing the total number of students sampled to 67. Students in the three selected schools (Table 4) were assigned randomly to treatment and control groups. Students in School A formed the Self-regulation Empowerment Training Group, students in School B formed the Scaffolding Group, and students in School C served as the Control Group exposed to Placebo (non-therapeutic activities).

Table 4

Sampled population

		Sampled Schools				
Sn	Name of Schools	SSS 1		SSS 2		
		Boys	Girls	Boys	Girls	Total
1	Ekuku-Agbor Secondary School, Ekuku	26	28	29	28	111
2	Ime-Obi Secondary School, Agbor-Obi	80	94	61	62	297
3	Irenuma Secondary School, Abavo	54	45	29	32	160
	Total	160	167	119	122	568

2.2. Data collection instrument

The instrument for data collection was titled “Dyscalculia Screening Scale Among Secondary School Students” (DSS). It was adapted from the Dyscalculia Screening Tool (DST) developed by Jeya & Pio Albina (2021). The original items were 36, but the researcher modified the instruments by adding 4 items, making the total number of items 40. In addition, some of the items were modified to suit the understanding and academic ability of the respondents. It was designed as a four-point rating scale with responses of: Never = 1, Rarely = 2, Often = 3, and Always = 4. It was scored over 160 (4 x 40), and responses were classified by the researcher as follows: 0-40 = no dyscalculia trait, 40 – 80 = low dyscalculia trait, 80 - 120 = moderate dyscalculia trait, and 120+ = severe dyscalculia trait.

2.3. Ethical considerations

The principals of the selected schools were informed, and then teachers of the randomly selected students were told to assist the researchers in explaining the reasons for the consent forms to the students. This was to improve the students’ confidence, while all respondents were assured of confidentiality and anonymity. Consent letters were signed and returned to the researcher, while those who refused were excluded before the questionnaires were administered.

3. RESULTS

Hypothesis 1: There is no significant difference in the dyscalculia pre-test means scores of secondary school students exposed to self-regulation empowerment training and scaffolding and the Control Group.

Table 5

Mean and standard deviation analysis of pretest scores of treatment and control groups

Group	N	Mean	Standard Deviation
Self-Regulation Empowerment Training	25	103.08	15.31
Scaffolding	23	106.57	18.10
Control	19	106.26	14.00
Total	67	105.18	15.80

Table 5 shows the results for self-regulation empowerment training with 25 participants having a mean of 103.08 and a standard deviation of 15.31; scaffolding with 23 participants having a mean of 106.57 and a standard deviation of 18.10, while the control group with 19 participants had a mean of 106.26 and a standard deviation of 14.00. To show if there is a significant difference, Analysis of Variance (ANOVA) was employed as presented in Table 2.

Table 6

ANOVA pretest scores of treatment and control groups

Group	Sum of Squares	Df	Mean Square	f	Sig. p-value
Between	176.674	2	88.337	.347	.708
Within	16293.176	64	254.581		
Total	16469.851	66			

$\alpha = 0.05$

The data in Table 6 showed an $F_{(2,64)}$ value =.347 and a p-value = .708; testing at an alpha level of 0.05, the p-value is greater than the alpha value. This revealed no significant difference. Therefore, the null hypothesis, which states that "there is no significant difference in the dyscalculia pre-test mean scores of secondary school students in treatment and control groups," was retained. This means that the groups were equivalent in dyscalculia mean scores before treatment.

Hypothesis 2: There is no significant difference in the dyscalculia post-test mean scores of secondary school students exposed to self-regulation empowerment training and scaffolding and the Control Group.

Table 7

Mean and standard deviation analysis of post-test mean scores of treatment and control groups

Group	N	Mean	Standard Deviation
Self-Regulation Empowerment Training	25	53.52	11.45
Scaffolding	23	51.43	12.97
Control	19	107.21	10.49
Total	67	68.03	27.41

Data in Table 7 shows that self-regulation empowerment training with twenty-five participants has a mean value of 53.52 and a standard deviation of 11.45; for scaffolding, twenty-three participants have a mean value of 51.43 and a standard deviation of 12.97, while the control group with nineteen participants has a mean value of 107.21 and a standard deviation of 10.49. The test of significance difference is shown in Table 7.

Table 8

ANOVA post-test scores analysis of treatment and control groups

Group	Sum of Squares	df	Mean Square	F	Sig p-value
Between	40764.890	2	20382.445	147.748	.000
Within	8829.050	64	137.945		
Total	49593.940	66			

α = 0.05

Table 8 shows an $F_{(2,64)}$ =147.748 and a *p-value* of .000, testing at an alpha level of 0.05; the p-value is less than the alpha value. This reveals a significant difference. This implies that the null hypothesis "there is no significant difference in the dyscalculia post-test mean scores among secondary school students in the treatment and control groups" is rejected. This means that there is a significant difference in the post-test means scores of treatment and control groups of secondary school students with dyscalculia in Ika South Local Government Area of Delta State.

Table 9

Post-hoc LSD multiple comparisons of post-test scores of treatment and control groups

(I) Group (II)	(J) Group	Mean Difference (I-J)	Std. Error	Sig. p-value
Self-Regulation Empowerment Training	Scaffolding	2.085	3.394	.541
	Control	-53.691*	3.575	.000
Scaffolding	SRET	-2.085	3.394	.541
	Control	-55.776*	3.641	.000
Control	SRET	53.691	3.575	.000
	Scaffolding	55.776*	3.641	.000

α = 0.05

Table 9 shows the mean difference between the participants exposed to Self-Regulation Empowerment Training and the Control group is -53.691 and a *p-value* of .000; which means that Self-Regulation Empowerment Training is effective in managing dyscalculia compared to the Control group. The mean difference between the participants exposed to Scaffolding and the Control group is -55.776 and a *p-value* of .000, which shows that Scaffolding is effective in managing dyscalculia compared to the Control group. However, the mean difference between the participants exposed to Self-Regulation Empowerment Training and Scaffolding is 2.085 and a *p-value* of .541. That means there is no difference between Scaffolding and Self-Regulation Empowerment Training in managing dyscalculia.

4. DISCUSSION

Results revealed no significant difference in the dyscalculia pretest means scores of secondary school students in treatment and control groups before treatment commenced. This indicated that all three groups were equivalent at the pretest regarding dyscalculia. The possible explanation is that all these students who were to participate in the intervention and control group were identified by the researcher as having dyscalculia traits that need intervention, using the benchmark score of 80 and above from the Dyscalculia Screening Scale (DSS). This implied that before remediation, dyscalculia traits prevailed among some of the learners in public secondary schools in Ika South Local Government Area of Delta State.

Results acknowledged that self-regulation empowerment training and scaffolding intervention programs were effective in managing dyscalculia traits among secondary school students. From the result, it was found that self-regulation empowerment training and scaffolding were effective in managing students with dyscalculia traits. This means that students exposed to self-regulation empowerment training and scaffolding

intervention programs showed significant improvement in their numeracy fluency and accuracy skills, which is evidence of effective management of dyscalculia traits. The reason for this finding might be that when students with dyscalculia traits have been exposed to treatment programs, they learn new skills for the management of dyscalculia traits. The finding corroborated the study of Kaushik and Jena (2021), which investigated self-regulation empowerment learning strategies and academic performance in students with learning difficulties, using the semi-experimental research with a pre-test, post-test control group design, and findings that revealed that self-regulation skills promote better academic and cognitive aptitudes. In the same vein, the study of Turmudi et al. (2019) investigated the effect of the teaching and learning mathematics strategy based on metacognitive scaffolding on instructional efficiency, which aligns with the research design and the result, which showed that the Metacognitive Scaffolding strategy fulfilled the direct effect on instructional efficiency as students improved on their mathematics performance. Furthermore, the study of Edekor (2020) on scaffolding, which employed a quasi-experimental research design, indicated a significant difference between students taught with the scaffolding strategy and the traditional method, in favor of the scaffolding strategy. Although this study compares self-regulation empowerment training with scaffolding, scaffolding showed superiority in its effect.

5. CONCLUSION

To manage cases of Dyscalculia in learners, several interventions have been employed by different researchers in different countries over the years. This study, however, improves the learning outcome of learners with Dyscalculia. It revealed that Self-regulation empowerment Training and Scaffolding were effective on students with Dyscalculia traits. It is hoped that the results of this study will lead to better identification and management of learners with dyscalculia in secondary schools in Delta State, specifically, and Nigeria in general. Thus, the following recommendations were made;

- School Guidance Counsellors should be proactive in the identification of dyscalculia traits among newly admitted students by administering the Dyscalculia Screening Scale test.
- School Guidance Counsellors should organize seminars/workshops to create awareness on the need for the use of Self-Regulation Empowerment Training and Scaffolding in managing dyscalculia
- Professional Counselling Associations (PCAs) should create awareness of the prevalence of dyscalculia among secondary school students through seminars/workshops.

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