Original research article

DIFFERENTIAL EFFICACY OF SELF-REGULATION EMPOWERMENT TRAINING AND SCAFFOLDING IN MANAGING DYSCALCULIA AMONG SECONDARY SCHOOL STUDENTS

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Abstract

The study examined the efficacy of self-regulation empowerment training and scaffolding in managing dyscalculia among public secondary school students in Ika South Local Government Area of Delta State. Two research questions were raised with their corresponding hypotheses, and tested at a 0.05 significance level. The study was quasi-experimental with a pretest, posttest, and control group. The study utilised the 3 × 3 × 2 × 2 × 3 factorial design. It consisted of two treatments (Self-Regulation Empowerment Training and Scaffolding) and a control group, which served as the independent variables. For this study, a multistage sampling procedure was used to select 67 participants from the population of 568 in three different public secondary schools. The instrument for data collection ws the Dyscalculia Screening Scale (DSS), adapted from the Dyscalculia Screening Tool (DST). The instrument reliability was established using Cronbach Alpha statistics, and a reliability coefficient of 0.823 was obtained. Descriptive and inferential statistics were used for data analysis. The results revealed no significant difference in the pretest dyscalculia mean scores of students in the treatment and control groups. It was found that Self-Regulation Empowerment Training and Scaffolding were efficacious in managing dyscalculia among secondary school students.

Keywords: *Dyscalculia; Efficacy; Scaffolding; Secondary school students; Self-Regulation Empowerment Training*

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 and Al-Hmouz, 2016). The cause of learning disabilities seems to be the malfunctioning of one area or another of the brain. The the brains of the disabled are wired differently from those of others; and this difference affects how they receive and process information (Osisanya et al., 2018). Due to these reasons, some categories of individuals do not interpret correctly what their senses perceive, therefore, they do not learn in the normal way other learners do. This group of learners fall under the category of learning disabilities/difficulties, and dyscalculia is one of them. The term dyscalculia is derived from a combination of Greek and Latin words. "Dys" comes from the Greek word, which means "difficulty", while "calculia" comes from the Latin word, and means "calculation" (Khing, 2016). 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 (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). Students with dyscalculia have little or no confidence in their ability to study numerical-related subjects, and have 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, p. 70). Dyscalculia has been observed to be prevalent in the United Kingdom (Snyder et al., 2016), in the United States of America (Haberstroh and Schulte-Körne, 2019), 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 researchers presume that this might be related to 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). The researchers believe that the poor performance rate in mathematics among students in National Examinations such as the West African Senior Secondary School Certificate Examinations (WASSCE) and National Examinations Council (NECO), might be related to, but not limited to dyscalculia among secondary school students in Nigeria as shown in Table 1.

Table 1 – Statistics of students' performance in mathematics in 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
Note: WAEC – West African Examinations Council (WAEC) (2016–2021) and National Bureau of Statistics, (2022)					

Table 2 – Statistics of students' performance in mathematics in 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
Note: NECO – National Examinations Council					

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

Self-regulation training strategies (SRET) represent an approach that has evolved within the field of cognitive and social skills (the self-regulation approach), and can adjust and eliminate the gaps among cognitive-behavioural theories (Karbasdehi et al., 2019). Self-regulated learning skills enhance autonomy among students, as they direct their endeavours to learning time management, self-monitoring, and physical and social-environmental regulation processes. Self-regulation empowerment programme 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 (Cleary et al., 2017; Karbasdehi et al., 2019). 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 aptitude in students with learning difficulties (Kaushik and Jena, 2021). 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 was more effective in students' academic achievement, as the students achieved better when compared to their counterparts in other treatment groups (Onah, 2022). According to Edekor (2020) who used Scaffolding Strategy in enhancing students performance in Mathematics among Senior High School in Keta Municipality, Ghana, he employed a quasi-experimental research design, indicated a significant difference between students taught with the scaffolding strategy and traditional method, in favour of the scaffolding strategy.

Scaffolding demonstrated a 33.0–34.5% increase in student learning achievement following its application, accompanied by a corresponding 90.4% decrease in mathematics anxiety levels (Kusmaryono et al., 2020). Scaffolding Strategy on the Teaching and Learning of Mathematics indicated that the meta-cognitive scaffolding strategy directly affected instructional efficiency (Turmudi et al., 2019).

Research goals

1. The goal is to determine the difference in dyscalculia pretest mean scores between secondary school students exposed to Self-Regulation Empowerment Training (SRET) and scaffolding, and those in the control group.
2. The goal is to determine the difference in dyscalculia posttest mean scores between secondary school students exposed to Self-Regulation Empowerment Training (SRET) and scaffolding, and those in the control group.

Sub-goals

1. There is no significant difference in the dyscalculia pretest mean scores of secondary school students exposed to self-regulation empowerment training and scaffolding, and the control group.
2. There is no significant difference in the dyscalculia posttest mean scores of secondary school students exposed to self-regulation empowerment training and scaffolding, and the control group.

Ethical considerations

The principals of the selected schools were informed, and then teachers of the rando-

mly 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, and all respondents were assured of confidentiality and anonymity. Consent letters were signed and returned to the researcher, and those who refused were excluded before the questionnaires were administered.

MATERIALS AND METHODS

The researcher employed quasi-experimental research with a 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 3 × 3 × 2 × 2 × 3 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 programme. All the groups were subjected to pretest and posttest.

Participants

The population was made up of 1,833 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. There were 899 male students and 934 female students, as shown in Table 3.

Table 3 – The population of secondary school students in Ika South Local Government Area of Delta State

ENROLLMENT FIGURES 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**

Note: Delta State Ministry of Education (2003)

Sample and sampling techniques

The study consisted of 67 participants who were 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 from school B, and 19 students selected from school C. Students in the three selected schools 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 a placebo (non-therapeutic activities) – Table 4.

Table 4 – Sampled population

SAMPLED SCHOOLS						
S.N.	Name of schools	SSS 1		SSS 2		Total
		Boys	Girls	Boys	Girls	
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**

Research 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 Adaikala Jeya and Pio Albina (2023). The original items were 36 but the researcher modified the instruments by adding four items, making the total number 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 × 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.

RESULTS

Sub-goal 1: There is no significant difference in the dyscalculia pretest mean scores of secondary school students exposed to self-regulation empowerment training and scaffolding. and the control group.

Table 5 shows the results of the self-regulation empowerment training, where 25 participants had a mean score of 103.08 and a standard deviation 15.31. For scaffolding, the 23 participants had a mean score of 106.57 and a standard deviation 18.10. The control group had 19 participants with a mean score 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 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**

The data in Table 6 shows $F^{(2.64)}$ value = 0.347 and a *p*-value = 0.708; 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 stating that "there is no significant difference in the dyscalculia pretest mean scores of secondary school students in the treatment and control groups" was retained. This indicates that the groups were equivalent in dyscalculia mean scores before treatment.

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	0.347	0.708
Within	16293.176	64	254.581		
Total	**16469.851**	**66**			
Note: α = 0.05					

Sub-goal 2: There is no significant difference in the dyscalculia posttest mean scores of secondary school students exposed to self-regulation empowerment training and scaffolding, and the control group.

Data in Table 7 shows that the 25 participants with self-regulation empowerment training had a mean value of 53.52 and a standard deviation of 11.45. For scaffolding, 23 participants had a mean value of 51.43 and a standard deviation of 12.97. In the control group, 19 participants had a mean value of 107.21 and a standard deviation 10.49. The test of significance difference is shown in Table 7.

Table 7 – Mean and standard deviation analysis of posttest mean scores of the 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**

Table 8 shows $F^{(2.64)}$ = 147.748 and a *p*-value of 0.000; testing at an alpha level of 0.05, the p-value is less than the alpha value. This reveals a significant difference, suggesting that the null hypothesis "there is no significant difference in the dyscalculia posttest mean scores among secondary school students in the treatment and control groups" must be rejected. Thus there is significant difference in the posttest means scores of the treatment and control groups of secondary school students with dyscalculia in Ika South Local Government Area of Delta State.

Table 8 – ANOVA posttest 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	0.000
Within	8829.050	64	137.945		
Total	**49593.940**	**66**			
Note: α = 0.05					

Table 9 shows that the mean difference between participants exposed to Self-Regulation Empowerment Training and the control group is –53.691, and the p-value is 0.000. This 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 the *p*-value is 0.000; which shows that Scaffolding is effective in managing dyscalculia when compared to the control group. However, the mean difference between the participants exposed to Self-Regulation Empowerment Training and Scaffolding is 2.085, with a *p*-value of 0.541. This means there is no difference between Scaffolding and Self-Regulation Empowerment Training in managing dyscalculia.

Table 9 – *Post-hoc* LSD multiple comparisons posttest 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 control	2.085 –53.691*	3.394 3.575	0.541 0.000
Scaffolding	SRET control	–2.085 –55.776*	3.394 3.641	0.541 0.000
Control	SRET scaffolding	53.691 55.776*	3.575 3.641	0.000 0.000
Note: α = 0.05				

DISCUSSION

The results revealed no significant difference in the dyscalculia pretest means scores of secondary school students in the treatment and control groups before treatment commenced. This indicates that, regarding dyscalculia, all three groups were equivalent at the pretest. A possible explanation is that the students who participated in the intervention and control groups 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). Hence before remediation, dyscalculia traits prevailed among some of the learners in public secondary schools in Ika South Local Government Area of Delta State.

The results indicated that self-regulation empowerment training and scaffolding intervention programmes were effective in managing dyscalculia traits among secondary school students. This means that students exposed to self-regulation empowerment training and scaffolding intervention programmes 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 are exposed to treatment programmes, they learn new skills for the management of dyscalculia traits. This finding corroborates with the study of Kaushik and Jena (2021), which investigated self-regulation empowerment learning strategies and academic performance in students with learning difficulties. It employed semi-experimental research with a pretest, posttest, control group design, and revealed that self-regulation skills promote better academic and cognitive aptitudes. Similarly, the study by Turmudi et al. (2019) examined the impact of a mathematics teaching and learning strategy based on metacognitive scaffolding on instructional efficiency. The results indicated that the Metacognitive Scaffolding strategy had a direct positive effect on instructional efficiency, as students showed improvement in 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 traditional method, in favour of the scaffolding strategy.

CONCLUSION

Over the years, different researchers in different countries have employed several interventions to manage cases of dyscalculia in learners. However, this study improves the learning outcome of learners with dyscalculia, showing that Self-Self-regulation empowerment Training and Scaffolding are 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, and Nigeria in general. Thus, the recommendations are as follows:

- School Guidance Counsellors should be proactive in identifying dyscalculia traits among newly admitted students by administrating a Dyscalculia Screening Scale test.
- School Guidance Counsellors should organise 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 on the prevalence of dyscalculia among secondary school students through seminars/ workshops.

Ethical aspects and conflict of interest

The authors have no conflict of interest to declare.

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