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Developing Students' Problem-Solving ability in Mathematics through Collaborative Learning Strategy in Secondary Schools

[1]Inalegwu Napoleon and [2]Okolie Alfred Chukwudi
[1,2]Department of Mathematics
Alvan Ikoku University of Education, Owerri, Imo State, Nigeria

Abstract

The study dealt with the development of students' problem-solving ability in mathematics through Collaborative Learning Strategy (CLS) in secondary schools in Owerri West Local Government Area of Imo State. Based on the objectives of the study, 3 hypotheses were addressed. The quasi-experimental research design was adopted in the study. Two coeducational schools were purposively selected for the study and a sample of 236 SS2 students from four intact classes were used for the study. A sample of 195 SS2 students was selected for the study. The data required for the study was collected using a researcher made objective test titled "Mathematics Achievement Test (MAT)". Kuder Richardson 20 formula (KR20) was used to arrive at a reliability coefficient of 0.90 for the instrument. The Collaborative Learning Strategy (CLS) was used to teach mathematics to the experiment group, while the Traditional Approach was used for the control group. To address the research issues, the collected data were examined using the mean and standard deviation, and the ANCOVA statistical technique was utilized to test the hypotheses at the 0.05 level of significance. The result of the study revealed that Collaborative Learning Strategy (CLS) enhanced students' problem-solving ability in mathematics which was evident in their improved achievement $F(1,188) = 188.485$. $P=0.000 <0.05$). *There was no significant difference between the problem-solving abilities of low and high achievers in mathematics as shown by their achievements* $F(1,188) = 1.541$. $P=0.216 >0.05$). *There was no interaction effect between Collaborative Learning Strategy (CLS) and students Gender* $F(1,188) = .112$, $P=0.739 >0.05$). *Based on the result it was recommended that Teachers should employ Collaborative Learning Strategy (CLS) in teaching mathematics at secondary school level to enhance students problem-solving ability.*

Keywords: *Collaborative Learning Strategy, Problem-solving, ability, Mathematics*

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Introduction

Mathematics is an umbrella subject that harbors all other science subjects and a light that illuminates other science subjects. Mathematics is considered as the mother of all sciences because it is a tool which solves problems of every other science (Kangarosworld, 2017). Chiu (2007) noted that as the science of pattern and logic, mathematics may be used to model a wide range of topics in the world's knowledge, including science. As most cultures' national curriculum attest, mathematics has become an essential subject in schools. Ayesha (2018) stated that Mathematics as a science, examines the logic of structure, quantity, and order. Mathematics is involved in every activity we indulge in and plays a role in building blocks for everything in our daily lives, including mobile devices, social media, art, money, engineering and sports, etc. There is hardly any aspect of human endeavor that act of mathematics is not operative. Similarly, Uwadiae (2014) defined mathematics as the core intellectual discipline and an essential instrument in science, commerce, and technology. It is a paradigm of thinking that encourages students to observe, analyze, and reason rationally about a problem and in communicating ideas. Nwoke (2020) stated that every nation's growth of information and communication technologies requires mathematics. A nation's level of technological and economic progress is correlated with its proficiency in mathematics.

Despite the unlimited importance associated with mathematics and its prerequisite position in the study of science related courses in higher education, students have always shown hatred, poor attitude and lack of interest in the subject. Undoubtedly, the situation led to persistently low performance in the subject area. Imoko and Jimin (2016) pointed that, A review of math achievement by students revealed that Nigerian students' performance is unsatisfactory. Suleiman and Hammed (2019) citing WAEC results from 2009-2014, revealed that secondary school students' performance in core subjects (mathematics inclusive) is on the decline. WAEC chief examiners report (2019) analysis showed that students had improved performance in mathematics than in the previous years. However, they exhibited poor knowledge in some important aspects of the subject leading to poor outcome in these areas. These include, among others, solving problems involving circles theorem, solving problems involving angles of elevation and depression. The consistent and unacceptable poor performance of students in mathematics at secondary school level is an indication that they have poor understanding of mathematical concepts and are weak in problem solving which impacts greatly on their achievement. Mathematics is all about solving problems which requires students to be creative, think critically, make decisions and employ novel approaches to resolve problems that look insurmountable. Elizabeth et al. (2018) found that one of the main reasons for poor academic achievement in science-related fields is the inability to solve problems. Esan (2015) mentioned that solving problems is a crucial life skill that requires coming up with a suitable solution for a situation that is fresh and different for each person solving an issue. Similarly, Vula et al. (2017) said that addressing problems requires a sophisticated cognitive process in which the solver must employ language knowledge to determine what is missing, identify the issue that needs to be resolved, and then formulate arguments to offer solutions. Prema and Sathiskumar (2021) argued that the goal of teaching mathematics is to enable students be effective and able to solve their problems which will show that learning mathematics is aimed at developing their cognitive and affective domain that can support problem solving abilities. A good problem-solving ability among mathematics students is exhibited in their ability to reasonably and effectively resolve mathematical problem situations resulting to an improved achievement. Madhu et al. (2015) argued that one of the key components of education is the capacity for problem-solving, which influences academic success. Success depends on solving problems, that's why it's been said to be the most important component of human behavior. Students'

academic success is greatly influenced by their capacity to solve problems, which is also gaining popularity as a critical skill in contemporary society. The lack of effective students' mathematical problem-solving ability could be blamed on the teachers' methodologies. The unrepentant use of traditional approach of teaching mathematics at secondary school level has continued to worsen the situation. To enhance the problem-solving ability of students in mathematics, there is urgent need for the application of innovative, student-centered and effective learning approach such as the Collaborative Learning Strategy (CLS).

Collaborative learning strategy (CLS) is a student-centered learning strategy that allows learners of different abilities to be arranged in a group of 2-5 students as the case maybe working together for the purpose of gaining knowledge and solving problems. All learners in the group have responsibility and contribute freely to the process of learning. Abdulwahab (2016) defined Collaborative learning as a method where students of varying skill levels work in small groups, and each member of the group is expected to learn from the teacher as well as assist other members of the group in their studies. Torre et al. (2017) opined that collaborative learning refers to a broad range of pedagogical strategies that involve students' or students' and teachers combined intellectual work. Students are typically engaged in groups of two or more, producing a product or collaboratively seeking insight, answers, or meanings. In the words of Nkrumah (2021) when appropriately managed by the math teacher, collaborative learning as a highly structured type of group work that emphasizes problem solving, inquiry, critical thinking, and independent study can help students succeed in their mathematical studies. In addition, students who participate in collaborative learning experience deeper learning, true paradigm shifts in their thinking, and the growth of positive interdependence and personal accountability. The high point of collaborative learning strategy (CLS) is that students improved in understanding mathematical concepts and problem-solving abilities through interaction and communication with others. Also, Akpan and Nkan (2022) noted that in collaborative learning strategy, group members can help one another through explanations, reminders, and questions when the group interactions are structured to ensure equitable participation. This is accomplished by assigning specific roles, alternating roles and activities, or requiring that consensus among group members be reached. Supporting the view, Akinoso et al. (2021) opined that in collaborative learning strategy, everyone in the group and the teacher share ideas, which improves the students' comprehension, problem-solving abilities, and way of thinking. Ali and Ali (2011) stated that collaborative learning strategy (CLS) encourages students to engage in conversation and discussion, improve their academic performance and psychological well-being, and hone their problem-solving abilities.

Research abounds on collaborative learning impacts students' academic achievements. Olanrewaju (2019) in a study revealed that collaborative learning techniques improved students' achievement in mathematics. Niyonsaba et al. (2022) reported that students who were taught collaborative learning outperformed those who were taught traditional lecture methods in the preparation and classification of oxides, based on a study on the effects of collaborative learning on students' academic performance in chemistry in three chosen secondary schools in the Nyamasheke district of Rewanda. Fakomogbon and Bolaji (2017)also discovered that when a collaborative learning approach was used, students' performance in the mobile learning experience and their ability to solve think-aloud-pair problems improved significantly. Abd Algani (2021) research on the effect of the collaborative learning technique on students' educational performance in math for primary school students in northern Israel found that collaborative learning enhanced students' comprehension of the mathematics topic, which improved their fluency of solutions,

versatility of methods, originality of resolution, and innovative thinking, as well as their ability to deal with sports exercises, leading to improved educational success. Aku et al (2022) found that educating basic science students with a collaborative approach enhanced their attitude and academic accomplishment in the subject of energy in their investigation of the impact of collaborative learning strategies on students' attitudes and achievements in Nasarawa State, Nigeria.

Gender is another factor that has come under debate in recent times due to its impact on students' mathematics and science outcome. It is a social construct which determines male and female functions in the society. There has not been any direct agreement on its influence on students' academic outcome in mathematics and other science subjects. It also determines how students regard science and mathematics learning as they are regarded as male subject areas while female students are more inclined to arts and linguistics. Oyediji and Okwilagwe (2015) claimed that there is no agreement on how instructional practices affect students' gender in relation to their academic performance on classroom subjects. Obunge (2021) reported gender differences in students' ability to solve problems relying on anxiety. Iji et al. (2017) in a study revealed that collaborative instructional strategy improved the achievement grades of both male and female students however, female students were more favoured in the classroom.

Collaborative learning strategy allows students of different ability levels to learn together, and this gives meaningful support to the low achievers. The high ability students find time to discuss and share knowledge with their lower ability counterparts which builds their confidence in problem solving. However, Shamusudin and Parr (2006) cited in Nkrumah (2021) reported that high achievers favor cooperative learning in groups of people with similar abilities over those with different abilities. It is implied that students who are more academically inclined would rather be in a group with other students who share their interests than with a student who is less capable. In the present study, students' problem-solving ability will be measured through their Mathematics achievements.

The earlier identified poor performance in mathematics among students in secondary education which was occasioned by poor problem-solving abilities, requires urgent and decisive attention as to reduce its ripple effects. The entire review did not also show any evidence of similar or remedial work done within the study area addressing the issue, leaving a gap in the literature.

Therefore, the study investigated the development of students' problem-solving ability in Mathematics through collaborative learning strategy (CLS) in secondary schools in Owerri West Local Government Area of Imo State.

Purpose of the Study

The present study examined the development of students' problem-solving ability in Mathematics through collaborative learning strategy (CLS) in secondary schools in Owerri West Local Government Area of Imo State. Specifically, the study determined whether;

1) Collaborative learning strategy (CLS) enhanced students' problem-solving abilities and resulted in better achievement in Mathematics.
2) Students with different learning abilities improved in their problem-solving abilities and achievements in mathematics through Collaborative Learning Strategy (CLS).

3) Any interaction effect exists between gender and Collaborative Teaching Strategy (CTS).

Hypotheses

The following hypotheses were formulated for the study

Ho_1: There is no significant difference between the mean achievement scores of students taught mathematics using Collaborative Learning Strategy (CLS) and those taught using the conventional Approach.

Ho_2: There is no significant difference between the mean achievement scores of High and low achievement students taught mathematics using Collaborative Learning Strategy (CLS).

Ho_3: There is no significant interaction effect between gender and Collaborative Learning Strategy (CLS).

Methodology

The study was a quasi-experiment type adopting the pre-test, post-test non-randomized control group design. The design was adopted to investigate the development of problem-solving abilities of mathematics students through collaborative learning strategy (CLS) in secondary schools since it was not feasible to randomly assign the individuals into control and experiment groups of the study due to the existing school program as such, intact classes were used for the study. The population of the study consists of all the senior secondary school two (SS2) students from the 12 public schools in the Owerri West Local Government Area of Imo State, Nigeria. Multi-stage sampling technique was applied in the study; Purposively, two co-educational schools were used for the study. In each of the schools selected, simple random sampling technique was applied in selecting 2 intact classrooms which were assigned to the experiment and control groups, respectively. This gave a sample size of one hundred and ninety-five (195) students. The control group had 89 students consisting of 41 males and 48 females, with 25 high learners and 64 low learners determined through their existing academic records. Also, the experiment group had 106 students consisting of 56 females and 50 males, with 38 high learners and 68 low learners. A 30-item objective test instrument titled "Mathematics Achievement Test (MAT)," constructed by the researcher, was used to collect data. The responses ranged from A-D with three distracters and one right answer for each question. A table of specification guided the construction of the questions based on the topic (Bearing) taught the students. The validity of the instrument was determined by 2 mathematics education experts and a measurement and evaluation expert. Their expert judgement guided the modification of the instrument where necessary. A pilot study was conducted to determine the reliability of the instrument which gave a reliability coefficient of 0.90 determined using Kuder Richardson 20 formula (KR_{20}). The two groups were pre-tested after which the experiment group was taught Bearing through a structured Collaborative Learning Strategy (CLS) lesson plan by a research assistant who was trained on the application of Collaborative Learning Strategy (CLS) for two weeks. In the experiment classrooms, the students were organized into groups of 2-5 members by the teacher. Each of the groups was presented a problem based on the topic Bearing that was taught them. They were allowed to develop a problem-solving plan among themselves. They were allowed to resolve the problems by sharing ideas, communicating with each other, every member had opportunity of contributing to the problem-solving process, high learners were allowed to carry the low learners along in the process of resolving the problems. The trained assistant guided them through the entire process, giving directives and making corrections

where necessary. The original mathematics teacher taught the same topic to the control groups using the traditional approach. After the four weeks that the study was conducted, both groups took a post-test which was scored over 100 percent. The Analysis of Covariance (ANCOVA)used to test hypotheses at 0.05 level of significance.

Results

Ho_1: There is no significant difference between the mean achievement scores of students taught mathematics using Collaborative Learning Strategy (CLS) and those taught using the conventional Approach.

Table 1: Summary of ANCOVA analysis

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	15157.267[a]	6	2526.211	34.852	.000
Intercept	18615.170	1	18615.170	256.820	.000
Covariate	11.815	1	11.815	.163	.687
Method	13661.882	1	13661.882	188.483	.000
Gender	45.594	1	45.594	.629	.429
Achievers	111.713	1	111.713	1.541	.216
Method * Gender	8.085	1	8.085	.112	.739
Method * Achievers	.585	1	.585	.008	.929
Error	13626.886	188	72.483		
Total	362758.000	195			
Corrected Total	28784.154	194			

Table 1 shows thatF(1,188) = 188.485. P=0.000 <0.05) for method. Based on the outcome, the alternative is supported and the null hypothesis is rejected. This implies that there is a significant difference between the mean achievement scores of students taught mathematics using Collaborative Learning Strategy (CLS) and those taught using the conventional Approach.

Ho_2: There is no significant difference between the mean achievement scores of High and low achievement students taught mathematics using Collaborative Learning Strategy (CLS).

Table 1 shows that F(1,188) =1.541. P=0.216>0.05) for achievers. Based on the result, the null hypothesis is upheld.

Ho_3: There is no significant interaction between gender and Collaborative Learning Strategy (CLS).

Table 1 shows that F(1,188) = .112, P=0.739>0.05) for method and gender. Based on the result, the null hypothesis is upheld.

Discussion

The result of the study revealed that collaborative learning strategy (CLS) enhanced students' problem-solving abilities in mathematics which was evident in the mean

achievement scores. The students taught mathematics using Collaborative Learning Strategies (CLS) had greater mean achievement scores than their counterparts taught using the conventional approach. The statistical analysis revealed a statistically significant difference between the mean achievement scores of students taught mathematics using Collaborative Learning Strategy (CLS) and those taught using the conventional approach. This outcome is suspected to have resulted from the nature of the instructional strategy as it allowed the students to own their study, make useful contributions in the learning process, interact and communicate with their peers, which increased their motivation and interest in the learning process. This result is in line with the report of Olanrewaju and Suleiman (2019) which found a significant difference between secondary school students exposed to collaborative learning techniques and those in the control group in terms of their achievement in mathematics learning. It also agrees with the report of Alamina, Adolphus, and Aderonmu (2013) which highlighted that using a collaborative learning strategy in the classroom was more effective at raising students' academic achievement than using a traditional classroom approach.

The study revealed that low achievers in the experiment group improved in achievement as well as their high achieving counterparts. This is an indication that collaborative learning Strategy can reduce the difference in problem solving abilities between low and high achievers. The instructional strategy created an avenue for the low learners to share knowledge with their high achieving peers and learn directly from them through direct interactions, and this supports the idea that students learn freely from their peers. The result disagrees with opinion of Shamusudin and Parr (2006) cited in Nkrumah (2021) as earlier reviewed.

Finally, the study revealed that there was no interaction effect between collaborative learning Strategy (CLS) and students' gender as both male and female students gained from the strategy as they showed no significant difference in their mean achievement scores. The instructional strategy gave no room for discrimination and stereotypes in the classroom. Every participant in the experiment group contributed to the learning process and had improved problem-solving ability resulting in their improved achievements. The result agrees with the report of Achufusi-Aka and Okpanachi (2021) which indicated that collaborative learning strategy motivates both male and female students to engage each other in an active social academic context than the conventional teaching method.

Conclusion

The study dealt with development of students' problem-solving ability in Mathematics through Collaborative Learning Strategy (CLS). The study revealed that Collaborative Learning Strategy (CLS) improved students' problem-solving abilities as indicated in their achievement, allowed for equal learning and achievement opportunities among students with different learning abilities and reduced gender difference in mathematics achievement.

Recommendation

Based on the result of the study, it was recommended that;

1) Teachers should employ Collaborative Learning Strategy (CLS) in teaching mathematics at secondary school level to enhance students problem-solving ability and achievement.
2) Collaborative Learning Strategy (CLS) should be adopted in teaching mathematics in secondary schools to ensure gender equity in achievement.

3) Conferences, workshops and seminars should be organized by Government to train mathematics teachers on the use of 21st century approaches in teaching mathematics in secondary schools as to enhance students' achievements.
4) Pre-service Teachers of mathematics should receive training on the application of Collaborative Learning Strategy (CLS) and other innovative approaches in teaching to enable students' benefit from them.

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