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Effects of Clues-Based Strategy on Students' Achievement in Mathematics among Secondary Schools in Yenagoa Metropolis of Bayelsa State

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ABSTRACT

The study examined the effects of a clues-based strategy on students' achievement in mathematics among secondary schools in Yenagoa, Bayelsa State, with gender considered as a variable of interest. In this strategy, students are given different sorts of clues that support them in exploring approaches, perspectives and alternatives to obtain the desired answers, rather than being told what they need to learn. A purposive sampling technique was used to select two schools, and from them a sample of 102 senior secondary 2 students was drawn to participate in the research which used a pretest-posttest control group quasi-experimental design. The students in the two schools were randomly assigned as experimental and control groups and taught using the clues-based strategy and modified lecture method, respectively for five weeks. A Mathematics Achievement Test (MAT) with reliability of 0.86 using the Kuder-Richardson Formula 21 (KR-21), and two instructional guides were used in the study. The mean, standard deviation and Analysis of Covariance (ANCOVA) were used for analysis. The findings of this study showed that students taught with the clues-based strategy significantly outperformed those taught with the modified lecture method, and that gender did not affect the students' achievement in mathematics. Amongst others, it was recommended that the clues-based strategy be adopted to teach mathematics to secondary school students, especially when teaching the application of mathematics concepts to real-life situations.

KEYWORDS: Achievement, Clues-Based Strategy, Gender, Mathematics, Modified Lecture Strategy

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INTRODUCTION

Mathematics is a broad and all-encompassing field centered on numbers and their operations. It is universally applicable, precise and spans across diverse contexts. Primarily due to its universal nature, mathematics has a broad expanse of functionality, including its various uses in daily lives and activities (Bailey, 2017; Pua & Macutay, 2020). Mathematics and its applications have over time, become intertwined with our society and essential for navigating the world around us today and thriving in it (Jayanthi, 2019). It is also a core element behind several major innovations that have shaped and transformed our world.

Mathematics is also fundamental for research works, which is important for the advancement and growth of knowledge. It is applied in commercial and economic contexts, which are indispensable for commercial and economic growth and stability (Capozzi, 2019). The study of mathematics is also useful for the development of fundamental 21st-century cognitive skills.

Despite the proven necessity of mathematics and its status as a core subject, contemporary research across educational tiers consistently highlights mathematics as one of the most challenging subjects for students to grasp and master (Varidzai Makondo & Makondo, 2020). Thus, mathematics has been associated with a trend of underachievement, which can be seen in most students inability to achieve credit passes in the O' level mathematics examination (Tobih, 2016; Zalmon & Wonu, 2017). This underachievement trend can be linked to the continued use of poor instructional strategies to teach mathematics, including the popular modified lecture method for mathematics instruction.

The modified lecture method just as the name depicts, is an enhanced or modified version of the lecture method. The lecture method involves students passively receiving information from the teacher, who explains concepts from the front of the class (Tan, 2017). This approach is criticized for its one-way communication flow, fostering rote learning, and not engaging students' curiosity (Farashahi & Tajeddin, 2018). It also lacks opportunities for independent learning, critical thinking, and creative abilities. Overall, the lecture method has been deemed largely ineffective for ensuring meaningful learning outcomes and high achievement in fields like mathematics. Though various modifications have been adopted over time by teachers to mitigate the teacher-centeredness of the lecture method and facilitate better student participation (through activities like questions and answer sessions), current achievement trends indicate that these modifications are not enough. Are there references explicitly using the term 'modified lecture method' that we can use to push the narrative as it does not stand out from the conventional teaching method which has Q & A inserted into it? Thus, it is necessary to explore other approaches through which mathematics can be effectively taught. One such approach that can be used for teaching mathematics is the introduction of clues to guide understanding and solving of mathematics problems.

CLUES-BASED STRATEGY

Clues refer to information bits that can be used to aid in solving problems, finding answers to questions, and uncovering findings. They provide suggestions that can help an individual better understand a problem and its solutions. We please need to provide at least 2 sources somewhere in the sentences in the paragraph below for this new teaching strategy we are advocating.

In the learning context, it can be hints, prompts, or guidance provided by teachers to students during teaching, to assist them navigate challenges and solve problems independently. This is particularly important as problem-solving is required for mathematics learning and across several other fields (Priemer et al., 2019). Instead of providing students with the answers to problems or leaving them to work it out entirely on their own, the teacher centers instruction around giving clues that stimulate better and critical thinking, and prompts students to analyze better. This facilitates students' active participation and engagement in their learning, and creates a supportive and inclusive environment that promotes confidence, collaboration, and the development of essential problem-solving skills.

In this strategy, students are given prompts that support them in exploring approaches, perspectives and alternatives to obtain the desired answers, rather than being spoon-fed what they need to learn. Dangers of spoon-feeding learning content to students include a lack of engagement or critical thinking skills, reduced creativity, and dependence on others (Manoor, 2023); all of which mitigate meaningful learning and subsequently poor learning outcomes.

The use of clues in classroom instruction empowers students to take charge and responsibility for their learning journey, which is a major recommendation of constructivism, one of the most prominent learning theories and guides today (Albert & Emery, 2017; Olivier, 2021). This fosters a sense of ownership, self-direction, and intrinsic drive toward academic success (Barron, 2021). Learning through clues has the added advantage of being a confidence booster, as deciphering clues and reaching solutions under teachers' guidance can instill a sense of accomplishment and willingness to tackle more complex challenges independently, and foster a lifelong love for learning.

Clues can serve as stepping stones in the problem-solving process, helping students break down complex issues into manageable components, thereby preparing students for success in their future careers and personal lives (Rodriquez, 2022).

Clues can be provided or introduced into mathematics classroom instruction through a variety of practices. These include when the students are actively engaged in mathematics problem-solving but face challenges, when students have expressly expressed a need for assistance, or while teaching in a scaffolding pattern. Scaffolding learning pattern refers to a pedagogical approach of providing temporary support and guidance to learners as they engage in challenging tasks or acquire new skills (Bowles et al., 2017; Puntambekar, 2021). In the context of clue-based teaching, teachers initially use clues then reduce them as students gain proficiency, allowing them to depend only on their cognitive processes and problem-solving abilities rather than on clues provided by teachers.

Several variables can actively influence students' learning outcomes in mathematics despite the instructional strategies used. These variables could also determine the effectiveness of instructional innovations, including the use of clues. One such variable is the gender of the students.

GENDER

Gender disparities in education could significantly determine students' educational trajectories and academic achievements. There are nuanced differences in various domains of cognitive abilities between males and females, which play a pivotal role in shaping their academic success (Esipenko et al., 2018; Yoon & Mann, 2017; Aucejo & James, 2021). Moreover, social norms and cultural expectations exert considerable influence on academic performance (Gonzalez et al., 2019; Nnamani & Oyibe, 2016). They could result in students harboring lower expectations for their success and undervaluing subjects that seem incompatible with their gender. Gender stereotypes further influence the daily (educational) experiences of students, as parents and teachers may inadvertently allocate more attention to individuals based on their perceptions of areas where the students are likely or supposed to perform better.

The use of a clues-based strategy is aligned with the zone of proximal development (ZPD), which is an area situated between what a learner can do independently and what remains beyond their current capabilities (Ponmani & Geetha, 2022; Silalahi, 2019). The focus here is on tasks and activities that a student may complete with the assistance of a more experienced person, usually a teacher, mentor, or peer. The theory is relevant to this study as it emphasizes that when a student is in the ZPD for a particular task (like solving mathematics), providing the appropriate assistance (like the use of clues to teach) will give the student enough of a "boost" to achieve the task. Furthermore, the theory emphasizes the usefulness of scaffolding in teaching, and clues can act as scaffolding tools to bridge the gap between what a student can independently accomplish and what lies just beyond their current capabilities.

Considering all the above, this study was designed to explore the use of clues as a potentially effective method to enhance students' achievement in mathematics and the assessment of gender as a moderator variable.

STATEMENT OF PROBLEM

Mathematics is one of the most important fields in the modern age, actively influencing virtually all facets of an individual's life. It has helped solidify its position as a core subject in the curriculum. However, despite these, available research points to students tending to struggle with the learning of mathematics. This underachievement can be attributed to the instructional strategy, which is predominantly used for mathematics instruction. This issue highlights the need to introduce innovations and approaches into the mathematics instructional process, and the use of clues in teaching is one strategy that may serve this purpose. However, no study has ever explored the use of clues in this context. Thus, this becomes imperative to determine the effectiveness of this strategy. This study also determines the moderating effects of gender on the dependent variable.

Research Questions

- What is the mean achievement score of students in mathematics when taught through clues-based strategy and those taught through modified lecture strategy?
- What is the mean achievement score of male and female students in mathematics when taught through clues-based strategy and those taught through modified lecture strategy?

Null Hypotheses

HO_1:There is no statistically significant difference in the mean achievement score of students in mathematics who are taught through a clues-based strategy and those who are taught through a modified lecture method.

HO_2:There is no statistically significant difference in the mean achievement score of male and female students in mathematics when taught through a clues-based strategy and those taught through a modified lecture method.

METHODOLOGY

This study adopted a "pre-test, post-test control group quasi-experimental design." The population of the study consists of all senior secondary school two (SS2) students in secondary schools in Yenagoa Local Government of Bayelsa State.A purposive sampling technique was utilized in choosing two public secondary schools, with those schools randomly sorted and assigned as the experimental or control group. The selection of schools was based on the following criteria:

- The schools must be public secondary schools.
- The mathematics classroom teachers at these schools must be reasonably professionally qualified and must have been teaching mathematics for a minimum of four years.
- The school's teachers and authorities must be willing to participate and make provisions for this study.

One intact class each from the schools was randomly selected for the control and experimental groups. For data collection purposes, three instruments were developed and utilized in this study. They include; "Instructional Guide on Clues-Based Strategy (IGCS), Instructional Guide on Modified Lecture Strategy (IGMLS), Mathematics Achievement Test (MAT)".

The IGCS and IGMLS were teaching guides for the control and experimental groups, respectively, on how to teach mathematics using the strategies. The MAT was a multiple-choice test of 25 questions to measure students' achievement in mathematics. MAT received face and content validity through expert reviews. The MAT had a reliability of 0.86 using Kuder-Richardson 21 (KR-21). What topics were taught, what areas did the MAT cover – new or old ones?

The data collection process lasted five weeks. The first week was used for the training of teachers to serve as research assistants in the selected schools. The pretest using the MAT was administered during the second week. Treatment with the instructional strategies was carried out during the third and fourth weeks. Here, students in the experimental group were taught mathematics using the IGCS and IGMLS, respectively. After the administration of the experiment, the MAT was readministered to the students as a post-test during the fifth week. Data was then analyzed using mean and standard deviation (for the research questions) and ANCOVA (for the hypotheses at 0.05 significant level).

RESULTS

Research Question One

"What is the mean achievement score of students in mathematics when taught through clues-based strategy and those taught through modified lecture strategy?"

Table 1 "Summary of Mean and Standard Deviation of Students' Pre-test and Post-test Scores on the Effects of Instructional Strategies on Students' Achievement in Mathematics"

Instructional Strategies	N	Pre-test Scores		Post-test Scores		Mean Gain
		Mean	STD	Mean	STD	
Clues-based Strategy	49	32.00	10.21	64.07	8.60	32.07
Modified Lecture	53	29.32	9.28	52.90	6.26	23.58
Total	102	30.60	9.78	58.26	9.32	27.66

Table 1 shows that the post-test mean score of students taught through the clues-based strategy (M = 64.07, SD = 8.60) is greater than the score of students taught through the modified lecture method (M = 52.90, SD = 6.26). The result further shows that the mean gain score of students taught through the clues-based strategy (32.07) is greater than the mean gain score of those taught through the modified lecture method (23.58). This result implies that students taught through a clues-based strategy performed better than their peers who were taught through the modified lecture method. Consequent to the observed difference, the ANCOVA was carried out to ascertain if the difference was statistically significant.

Research Question Two

"What is the mean achievement score of male and female students in mathematics when taught through clues-based strategy and those taught through modified lecture strategy?"

Table 2 "Summary of Mean and Standard Deviation of Pre-test and post-test scores on the Effects of Instructional Strategies on Male and Female Students Achievement in Mathematics"

Instructional Strategy	Gender	N	Pre-test Scores		Post-test Scores		Mean Gain
			Mean	STD	Mean	STD	
Clues-based Strategy	**Male**	20	32.41	8.31	62.82	8.47	30.41
	Female	29	31.71	11.47	64.93	8.74	33.22
	Total	49	32.00	10.21	64.07	8.60	32.07
Modified Lecture	**Male**	23	27.29	10.06	52.30	6.09	25.01
	Female	30	30.87	8.48	53.35	6.45	22.48
	Total	53	29.32	9.28	52.90	6.26	23.58
Total	**Male**	43	29.67	9.53	57.20	8.95	27.53
	Female	59	31.28	9.99	59.04	9.58	27.76
	Total	102	30.60	9.78	58.26	9.32	27.66

Table 2 shows that for students taught mathematics through clues-based strategy, the post-test mean score of female students (M = 64.93, SD = 8.74) is greater than those of male students (M = 62.82, SD = 8.47). Similarly, for the students taught through the modified lecture method, the post-test mean score of female students (M = 53.35, SD = 6.45) is greater than the scores of male students (M = 52.30, SD = 6.09). The total post-test mean score of female students (M = 59.04, SD = 9.58) is greater than those of male students (M = 57.20, SD = 8.95). Furthermore, the table shows that the total mean gain score of female students (27.76) is slightly greater than that of male students (27.53). Consequent to the observed differences, the ANCOVA was carried out to ascertain if the difference was statistically significant.

Null Hypothesis One

"There is no statistically significant difference in the mean achievement score of students in mathematics when taught through clues-based strategy and those taught through modified lecture strategy."

Table 3 "One-way Analysis of Covariance of the Post-test Mathematics Achievement Scores of Students Taught Through the Clues-Based Strategy and those Taught with the Modified Lecture Strategy"

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	3178.761[a]	2	1589.381	28.161	.000	.363
Intercept	31740.335	1	31740.335	562.385	.000	.850
Pre-test	1.061	1	1.061	.019	.891	.000
Instructional Strategies	3133.274	1	3133.274	55.516	.000*	.359
Error	5587.442	99	56.439			
Total	355008.883	102				
Corrected Total	8766.203	101				

"a. R Squared = .363 (Adjusted R Squared = .350) *Sig at 0.05 alpha level."

The result in Table 3 shows that there is a significant main effect of instructional strategy on students' post-test scores, $F(1,99) = 55.516$, $p < 0.05$, partial eta squared = .359. This gives an effect size of 35.9%. Thus, the null hypothesis, which states that "there is no statistically significant difference in the mean achievement score of students in mathematics when taught through clues-based strategy and those taught through modified lecture strategy," was rejected.

Null Hypothesis Two

"There is no statistically significant difference in the mean achievement score of male and female students in mathematics when taught through a clues-based strategy and those taught through a modified lecture strategy."

Table 4 "Two-way Analysis of Covariance of the Post-test Mathematics Achievement Scores of Male and Female Students Taught through Clues-Based Strategy and those Taught through the Modified Lecture Strategy"

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	3246.136[a]	4	811.534	14.260	.000	.370
Intercept	31274.402	1	31274.402	549.562	.000	.850
Pre-test	1.862	1	1.862	.033	.857	.000
Instructional Strategies	2979.354	1	2979.354	52.354	.000	.351
Gender	62.739	1	62.739	1.102	.296*	.011
Instructional Strategies * Gender	6.054	1	6.054	.106	.745*	.001
Error	5520.067	97	56.908			
Total	355008.883	102				
Corrected Total	8766.203	101				

"a. R Squared = .370 (Adjusted R Squared = .344), *Sig at 0.05 alpha level"

The result in Table 4 shows that there is no significant interaction effect of gender and instructional strategies on students' posttest scores, $F(1, 97) = .106$, $p > 0.05$, partial eta squared = .001. This gives an effect size of 0.1%. Thus, the null hypothesis, which states that "there is no statistically significant difference in the mean achievement score of male and female students in mathematics when taught through clues-based strategy and those taught through modified lecture method," was accepted.

DISCUSSION OF FINDINGS

The study's findings showed "statistically significant difference in the mean achievement score of mathematics students who are taught through a clues-based strategy and those who are taught through a modified lecture method".

This finding agrees with Vernandes (2019) who explored the "influence of context clues strategy on the reading achievement of tenth-grade students" and reported a significant influence of context clues strategy on students' achievement. The finding also agrees with that of Firdus (2016) who explored the "use of contextual clues techniques to improve students' achievement in English vocabulary" and reported that the contextual clues technique was effective in improving the students' achievement.

The finding disagrees with that of Mirza (2016), who considered the "effects of context clues on IPS students' reading comprehension" and reported that there is no significant effect of context clues on students' reading comprehension.

The study's findings also showed that "there is no statistically significant difference in the mean achievement score of male and female students in mathematics when taught through clues-based strategy and those taught through modified lecture methods".

This finding agrees with that of Mirza (2016), who considered the "interaction effects of gender in a study on the effects of context clues on IPS students' reading comprehension" and reported that there is no significant main or interaction effect of gender on the student's reading comprehension. The finding also agrees with that of Ihechukwu (2020), who assessed the "impact of the scaffolding approach on secondary school students' achievement in mathematics" and reported no significant difference in the mean achievement of male and female students taught mathematics using the scaffolding instructional strategy.

This finding disagrees with that of Okigbo et al. (2021), who assessed gender differences in the "effect of scaffolding instructional strategy on secondary school student's academic achievement in Mathematics" and reported that gender significantly influenced the academic achievement of students taught with scaffolding instruction in favor of male students.

CONCLUSION

Based on the study's findings, it can be concluded that the clues-based strategy is effective for teaching mathematics to students. The strategy is better than the modified lecture method. Gender does not affect the students' mathematics achievement; thus, male and female students learn mathematics in similar patterns and as well as each other.

RECOMMENDATIONS

- Mathematics teachers should adopt the clues-based strategy for teaching mathematics, especially when applying the concept to real-life activities.
- The government and other educational authorities should organize regular in-service training through seminars, conferences, etc., to equip teachers with knowledge on how to implement innovative instructional strategies like clues-based teaching.
- Teacher training institutions should also expose future educators to the need for such innovations in instructional strategies and how they can be implemented.
- Educational planners and policymakers should include provisions for and encourage the use of innovative instructional techniques in their plans.

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