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Effect of Metacognition on Secondary School Students' Performance in Mathematics in Gwer-East Local Government Area of Benue State

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ABSTRACT
The study on effect of metacognition on secondary school students' performance in mathematics in Gwer-East Local Government Area of Benue State was an attempt to ascertain the effect of metacognitive strategy on students' performance in mathematics and to determine the effect of metacognitive strategy on male and female students' performance in mathematics. The study used a quasi-experimental design. 120 senior secondary one students (SSS1) were used. The experimental group were expose to metacognitive teaching approach while the control group were taught mathematics using the conventional method. The instrument used for data collection was Metacognitive Mathematics Performance Test (MMPT) with a reliability of 0.76 using Kuder-Richardson formula 20. Two hypotheses were formulated and tested at 0.05 level of significance. Analysis of Covariance (ANCOVA) was used to test the hypotheses. Results from the study revealed that students taught mathematics using the metacognitive method approach performed better than those taught mathematics with conventional teaching approach. The study also revealed that both male and female students in the experimental group had a similar performance. The study recommended among others that, rather than viewing mathematics only as a subject or content to be taught, instructors can see them as opportunities for learners to reflect on their learning processes. Teachers can teach learners to use mnemonics to recall steps in a process, such as the order of mathematical operations.

I. INTRODUCTION
All over the world, there has been an increasing interest on how to enhance the academic performance of students in Mathematics. The quest for this has sent researchers all over the world into the field of inquiry where a lot of information has been gathered to how and why students perform poorly in Mathematics and the strategies employed to conquer the impediment. Dyscalculia which is a learning difficulty that causes students to struggle with formulas, shapes, and number-related concepts has been a great stumbling block for students to comprehend and process Mathematical problems (Tokani, 2018). These students usually fall far behind their peers in Mathematics and have trouble with number-related problems that do not improve with the ongoing practice.

Educational psychologists have long promoted the importance of metacognition for supporting student's learning and it continues to be a rapidly growing field of interdisciplinary research (Emily, 2011). Metacognition is one's ability to use prior knowledge to plan strategy for approaching a learning task; take necessary steps to problem solve, reflect on and evaluate results, and modify one's approaches as needed (Donna, 2016). It helps learners choose the right cognitive tool for the task and plays a critical role in successful learning. John Flavell originally coined the term metacognition in the late 1970s to mean "cognition about cognition phenomena" or more simply "thinking about thinking" (Flavell, 1979). It has been observed that metacognitive strategies can help students have more effective learning process in mathematics. Teacher's level of metacognitive strategy use has a linear relationship with academic success (Belet & Guven, 2011). Metacognitive strategies are the strategies that teachers often apply to help the students in understanding how they learn different skills in the learning environment. It helps the students in determining how they carry out the thinking processes (Oxford, 2013). Ideally, these processes make students aware of their own learning capabilities. Therefore, Mathematics teachers often use it in order to help the learners to become more strategic thinkers. It helps in influencing the brain processes that aid individuals in solving routine problems. It also involves scientific methods that can help in the assessment of one's thought process.

Intrinsically, many people rely on metacognition to achieve active learning.

Mathematics thinking is important for all members of a modern society as a habit of the mind for its use in the workplace, business, and for personal decision making. Mathematics is fundamental to understanding science, engineering, technology and economics (Amuta, 2014). It is crystal clear that the effect of metacognition or metacognitive strategies on the performance of students in Mathematics can never be embellished or overstressed. Despite the popular belief that Mathematics is about memorizing and precisely following algorithms and procedures, Mathematics is actually a subject of critical thinking, problem-solving and creativity (Boaler, 2019).

Secondary school mathematics is aimed at developing learners understanding of basic scientific phenomena and the application of scientific ideas to everyday life (Hassan, Abari, Aruwa, & Ndanusa, 2017). The objectives of Mathematics curriculum at the secondary school level are to: Provide basic literacy of mathematics for functional living in the society; Acquire basic concepts and principles of mathematics as a preparation for further studies; Acquire essential scientific skills and attitude as a preparation for technological application of mathematics and stimulate and enhance creativity (FRN, 2004).

Performance is the measure of what the students have accomplished or done. It can be accessed through test, assignment or examination results. A high performance result comes from appropriate behavior and the effective use of required knowledge, skills and competencies (Harrison, 2021). There is a large body of international research on sex differences in academic performance in mathematics. Education has been considered among the basic rights of human beings. From the learning perspective, the sex has seemed to play a significant role. It plays an essential role in motivation, attitudes, and achievement of students (Mousa, 2017).

Sahin and Kendir (2013) carried out a study in Ngide University Turkey to determine whether there was a significant difference in the achievement between the experimental group, which was taught to solve mathematical problems via metacognitive strategies, and the control group, which was taught mathematics in accordance with traditional approaches. The finding suggested that metacognitive strategies improved the students' achievement at a higher level when compared to traditional approaches.

Hyde, Rozek, Clarke and Hulleman (2016) performed a meta-analysis of 100 studies. They yielded 254 independent effect sizes, representing the testing of 3,175,188 Ss. Averaged over all effect sizes based on samples of the general population, d was -0.05, indicating that females outperformed males by only a negligible amount.

In this regard, the main purpose of this study is to investigate the effect of metacognition on secondary school students' performance in mathematics in Gwer-East Local Government Area, Benue State. Specifically, it is to:

1. To determine the difference in the mean performance scores of secondary school students taught mathematics using metacognition and those taught without metacognition.
2. To determine the difference in the mean performance scores of male and female secondary school students taught mathematics using metacognition.

Research Questions: This study provided answers to the following research questions:

1. What is the difference in the mean performance scores of secondary school students taught mathematics using metacognition and those taught without metacognition?
2. What is the difference in the mean performance scores of male and female secondary school students taught mathematics using metacognition?

Research Hypotheses: The following hypotheses was formulated to guide the study;

1. There is no significant difference in the mean performance scores of secondary school students taught mathematics using metacognition and those taught without metacognition
2. There is no significant difference in the mean performance scores of male and female secondary school students taught mathematics using metacognition

II. METHODOLOGY

The design adopted for this study was quasi-experimental design. The population for this study are all the senior secondary one (SS1) students in the co-education secondary schools in Gwer-East Local Government Area of Benue State. The sample of students for this study was 120 students drawn from the six secondary schools.

For the purpose of this research work, Metacognitive Mathematics Performance Test (MMPT) was used. The MMPT is a test instrument that covers all the areas of Geometry that will be taught with regard to this study. The MMPT is a fifty (15) items multiple choice (with options A – D) instrument prepared for SS1. The instrument was

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administered to a few respondents in pre-test exercise. The result of pre-test was used to calculate the reliability coefficient of the MMPT using the Kuder Richardson formula 20 which gives 0.76 showing that the instrument was reliable to be administered to the entire respondents.

The researcher administered the pre-MMPT and post-MMPT to all the SS1 students in the two groups. The pre-MMPT and post-MMPT were administered to the selected groups in different schools to avoid communication between the two groups. Data collected were analyzed using descriptive statistics of mean and standard deviation to answer the research questions while the hypotheses were tested at 5% level of significance using the Analysis of Covariance (ANCOVA).

III. RESULTS

The data is presented according to research questions and hypotheses.

Question 1: What is the difference in the mean performance scores of secondary school students taught mathematics using metacognition and those taught without metacognition?

Table 1: Mean Performance Scores and Standard Deviation

Group	Pretest		Posttest		
	$\bar{x}$	SD	$\bar{x}$	SD	Mean Difference
Metacognitive Approach	50.87	10.55	64.40	10.86	13.93
Conventional Approach	50.42	11.38	58.75	10.87	8.33
Total	**50.64**	**10.93**	**61.58**	**11.88**	**5.60**

In table 1, the mean pretest scores for the metacognitive application group is 50.87 with standard deviation 10.55 and the mean pretest for the conventional method group is 50.42 with a standard deviation of 11.38. This implies that before the administration of the test, the both groups were at the same level of knowledge. However, the mean of posttest for the metacognitive application method group is 64.40 with a standard deviation of 10.86 while the mean of the posttest score for the conventional method group is 58.75 with a standard deviation of 10.87. The mean difference in the experimental and control group is 13.93 and 8.33 respectively. From the mean scores for both groups, it could be seen that the metacognitive application method group has a higher mean score in mathematics than the conventional method group. To prove if the mean difference in the performance scores of the students between the two groups is significant, hypothesis 1 was tested at 0.05 level of significance.

Hypothesis 1: There is no significant difference in the mean performance scores of secondary school students taught mathematics using metacognition and those taught without metacognition.

Table 2: Summary of ANCOVA Result of Students Performance in both groups

Source	Type III Sum of squares	df	Mean Square	F	Sig.
Corrected Model	12222.290^a	2	6111.145	268.089	.000
Intercept	1440.819	1	1440.819	63.207	.000
pretest	11264.615	1	11264.615	494.167	.000
group	826.330	1	826.330	36.250	.000
Error	2667.035	117	22.795		
Total	469867.000	120			
Corrected Total	14889.325	119			

a. R Squared= .821 (Adjusted R Squared= .818)

From table 2, the p-value for groups is 0.000. Hence p<0.05, the null hypothesis is rejected. This implies that there is a significant difference between the metacognitive method group and the conventional method group. It therefore means that the students that were taught mathematics using metacognitive approach perform better than those taught using the conventional approach.

Question 2: What are the difference in the mean performance scores of male and female secondary school students taught mathematics using metacognition?

Table 3: Mean Performance Scores and Standard Deviation of male and female students

Sex	Pretest		Posttest		
	$\bar{x}$	SD	$\bar{x}$	SD	Mean Difference
Male	51.30	8.43	65.77	9.05	14.47
Female	50.43	12.46	63.03	12.42	12.60
Total	**50.86**	**10.55**	**64.40**	**10.86**	**1.87**

In table 3, the mean performance score of male and female students in the metacognitive teaching method group in pre-test is 51.30 and 50.43 with standard deviation of 8.43 and 12.46 respectively. This implies that both the male and female students in the metacognitive application method group were at the same level of knowledge in mathematics before the treatment. However, the mean performance scores in mathematics for the male and female students in the posttest of the metacognitive application method group are 65.77 and 63.03 with a standard deviation of 9.05 and 12.42. There is no much mean difference between the two groups This implies that both the male and female students in the metacognitive application method group improved upon their performance in mathematics.

Hypothesis 2: Hypothesis Three

There is no significant difference in the mean performance scores of male and female secondary school students taught mathematics using metacognition.

Table 4: ANCOVA Result for the Performance of male and female Students in the metacognitive approach Group

Source	Type III Sum of squares	df	Mean Square	F	Sig.
Corrected Model	5436.321[a]	2	2718.160	101.792	.000
Intercept	839.958	1	839.958	31.455	.000
pretest	5324.254	1	5324.254	199.387	.000
gender	2.870	1	57.095	2.138	.149
Error	1522.079	57	26.703		
Total	255800.000	60			
Corrected Total	6958.400	59			

a. R Squared= .781 (Adjusted R Squared= .774)

In table 7, the result shows that the covariance is not significantly the same with the dependent variable thus a sig value of .000. However, the significance value of posttest of male and female students within the group is 0.149. Hence p> 0.05, the null hypothesis is accepted. This result shows that there is no significant difference in the mean performance scores in mathematics between the male and female students in metacognitive application method group. This implies that both the male and female students performed equally in the mathematics taught during this study.

IV. DISCUSSION

From table 1, the mean pretest scores for the metacognitive application group is 50.87 and the mean pretest for the conventional method group is 50.42. From the mean scores, it is revealed that the subjects of the study were at the same entry level in their knowledge of mathematics before the commencement of the treatment. However, the mean of posttest for the metacognitive application method group is 64.40 while the mean of the posttest score for the conventional method group is 58.75. From the mean scores for both groups, it could be seen that the metacognitive application method group has a slightly higher mean score in mathematics than the conventional method group. Hypothesis 1 confirms this in table 2 where the significant value of the dependent variable (posttest) in the two methods is 0.000. Since $p<0.05$, the null hypothesis is rejected. It shows that there is a significant difference in the mean performance scores of secondary schools students taught mathematics in experimental group and control group. This reveals that students taught mathematics with metacognitive application improved on their performance in mathematics more than those taught mathematics with the conventional teaching method. This agrees with the findings of Sahin and Kendir (2013) which carried out a study in Nigde University, Turkey to determine whether there was a significant difference in the achievement between the experimental group, which was taught to solve mathematical problems via metacognitive strategies, and the control group, which was taught mathematics in accordance with traditional approaches and discovered that metacognitive strategies improved the students' metacognitive skills at a higher level than traditional approaches.

From table 3, the mean performance score in mathematics of male and female students in the metacognitive teaching method pre-test is 51.30 and 50.43. This implies that both the male and female students in the metacognitive application method were almost at the same level of knowledge in mathematics before the treatment. However, the mean performance scores in mathematics for the male and female students in the posttest of the metacognitive application method group are 65.77 and 63.03. This implies that both the male and the female students in the metacognitive application method group improved upon their interest in mathematics but a little higher with the male students. However, there is no much difference between the male and female students mean performance scores in mathematics even though the male students slightly performed above their female counterpart. To ascertain the significance of this finding, hypothesis 2 in table 4 was tested at 5% level of significance. In table 4, the result shows that the covariance is not significantly the same with the dependent variable thus a significant value of 0.000. However, the significance value of posttest of male and female students within the group is 0.149. Hence $p>0.05$, the null hypothesis is accepted. This results shows that there is no significant difference in the mean performance scores in mathematics between male and female students in metacognitive application method group. This implies that both the male and female students performed equally in the mathematics taught during this study. The mean performance scores of male and female students using metacognitive method did not differ statistically significantly. This indicates that both the male and female students performed equally, though the male students in metacognitive application method performed slightly higher than their female counterparts. The result of this findings disagrees with the findings of Hyde et al. (2000) which conducted a study to investigate the difference in the performance scores of male and female students in mathematics and concluded that gender differences in the performance scores in mathematics were in favour of the female students.

V. CONCLUSION

We live in a society that demands a high level of results in all spheres of life. This requires birthing of citizens who possess higher-order problem solving skills. This has given mathematics education a role that is very pertinent and prominent among many. Hence our societies needs to accommodate mathematical reasoning for its daily survival and advancement. With a great need for problem-solving abilities, many educators are concerned about the most effective way to teach mathematics in our schools. By applying meta-thinking strategies in Mathematics, learners can be more aware of their own control over their success at tasks. They can also adjust their thinking strategies as they go about their tasks to ensure optimum outcomes.

Research shows that metacognitive skills can be thought to students to improve their learning of Mathematics. Teaching of thinking involves teaching learners about their mental processes and how these can be used for problem solving. This involves or requires teachers to intervene at the level of the mental process and teach individuals what processes to use, when, how to use them, and how to combine them into workable strategies for task solution.

The above review also suggests that instructors can encourage learners to become more strategic thinkers by helping them focus on the ways they process information. Self-questioning and discussing their thought processes with other learners are among the ways that teachers can encourage learners to examine and develop their metacognitive processes. Rather than viewing mathematics only as a subject or content to be taught, instructors can see them as opportunities for learners to reflect on their learning processes. Teachers can teach learners to use mnemonics to recall steps in a process, such as the order of mathematical operations. Teachers should also teach students how their brain are wired for growth. The beliefs that students adopt about learning and their own brain will affect their performance. Research shows that when students develop a growth mindset and a fixed mindset, they are more likely to engage in reflective thinking about how they learn and grow.

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