EFFECT OF METACOGNITIVE INSTRUCTIONAL STRATEGY ON SECONDARY SCHOOL STUDENTS ACADEMIC ACHIEVEMENT IN GEOMETRY IN IDEMILI NORTH LOCAL GOVERNMENT AREA

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Abstract

The study investigated the effect of metacognitive instructional strategy (MIS) on secondary school students' academic achievement in geometry in Idemili North Local Government Area of Anambra State. Two research questions and three null hypotheses tested at 0.05 level of significance guided the study. The study adopted a quasi-experimental pre-test post-test nonrandomized control group design. Ninety-eight (98) senior secondary one (SS1) students from two co-educational government owned secondary schools in Idemili North were sampled from a population of 3363 using purposive and simple random sampling techniques formed the sample for the research. Achievement Test on Geometry (ATOG) constructed by the researcher containing 50 multiple choice questions was used to collect data on students' academic achievement in geometry. The ATOG and lesson plans were validated by three experts, one from measurement and evaluation and two from science education all from Nnamdi Azikiwe University, Awka. Kudder-Richardson Formula 20 was used to establish a reliability coefficient of 0.80. Treatment procedure mean, standard deviation and analysis of covariance were used for data analysis. The findings revealed that MIS specifically the regulatory self questioning strategy (RSQS) significantly enhanced the achievement of SS1 students in geometry more than the conventional method. Also there is no significant difference on the effect of RSQS on male and female students' academic achievement in geometry. Based on the findings of the study, it was recommended among others that; Mathematics teachers should adopt RSQS when planning their lessons to enhance students' interaction with each other and the learning materials to facilitate effective learning.

Keywords: Metacognitive instructional strategy, academic achievement, mathematics

Introduction

Mathematics is one of the core science subjects taught at senior secondary schools in Nigeria. Mathematics can be described as the subject of figures or science of size and figures. Mathematics is the abstract science of number, quantity, and space, either as abstract concepts (pure Mathematics), or as applied to other disciplines such as physics and engineering (applied Mathematics). However, many mathematicians viewed Mathematics in various ways based on its activities and importance. It can also be define as the science of numbers and their operations, interrelations, combinations, generalizations, and abstractions and of space configurations and their structure, measurement, transformations, and generalizations. *Algebra, arithmetic, calculus, geometry, and trigonometry are branches of Mathematics.* This shows that Mathematics has different *branches* and in the context of this study, one such *branch* is geometry.

Geometry is the branch of Mathematics concerned with the properties and relations of points, lines, surfaces, solids and higher dimensional analogues Stand-Network (2017) defined geometry as a branch

of Mathematics concerned with shape, size, relative position of figures, and the properties of space. Geometry arose independently in a number of early cultures as a body of practical knowledge concerning lengths, areas, and volumes, with elements of a formal mathematical science emerging in the West as early as Thales of Miletus. Alfred (2021) opined that geometry is the branch of Mathematics concerned with the shape of individual objects, spatial relationships among various objects, and the properties of surrounding space. Collin (2021) added that geometry is a branch of Mathematics concerned with the properties and relationships of lines, angles, curves and shapes.

Mathematical thinking and reasoning begins in students long before it is taught through any sort of schooling. Beginning as infants, humans are attracted to patterns, designs and shapes. These shapes and designs are the very foundational level of the mathematical field of geometry. Geometry is everywhere; angles, shapes, lines, line segments, curves, and other aspects of geometry are in every single place one looks, even the nature also has an abundance of geometry. Patterns can be found on leaves, in flowers, in seashells and many other places. Even the human bodies consist of patterns, curves and line segments. It is through the observation of nature that scientists have begun to explore and explain the more basic principles now accepted as scientific truths. At the most basic level, geometric principles occur all around man. Mankind craves geometrical principles to explain events occurring within the natural world. Home builders, interior designers, landscape designers all rely on geometric principles to attract the eye of prospective customers.

Despite the recognition given to Mathematics as one of the subjects upon which technological and economic development rests, it is very disappointing to note that students' achievement in the subject at both internal and external examinations had remained persistently poor, especially geometry as observed by Shriram (2021). This was confirmed by the West African Examination Council (WAEC, 2020) and National Examination Council (NECO, 2020) on analysis of students' performance in West African Senior Secondary School Certificate Examination in Mathematics and National Senior Secondary School Certificate Examination in Mathematics respectively. The WAEC Chief Examiner8's report (2020) for Mathematics observed that majority of the candidates exhibited significant weakness in translating word problems to mathematical expressions, solving problems that involves; circle theorems, mensuration, geometry and cyclic quadrilaterals, angles of elevation and depression. However, some areas of the syllabus that were also reported to be poorly attempted by majority of the candidates included: geometry (circle theorems and angles on parallel lines). The WAEC, Chief Examiners and NECO, Chief Examiners (2016; 2017; 2018 and 2019) had earlier observed also that majority of the candidates avoided the questions on geometry (construction). Some of those who attempted it did not go beyond constructing angles 90^0 and 120^0 among other weaknesses. It therefore seems that there has been a gap between curriculum planners' intention and what goes on in Mathematics classroom.

A lot of factors have been pointed at as being responsible for the poor achievement of students in Mathematics. Some of these factors include inadequate instructional facilities, poor retention ability among students, teaching and learning methods, students' lack of interest and motivation. Generally, science education instructional approach, especially lecture-based instructions is the oldest teaching methods applied in educational institution. It is one way channel of communication of information were students' involvement is just to listen and sometimes pen down some notes if necessary during the lecture (Robert, 2021). These approaches do not engage students in learning; they are more of teacher-centered than learner centered. Here emphasis seems to be on teaching than learning with less attention

on the "processes of learning or "how" the students learn. Abei (2020) also observed that traditional teaching method relatively help students in critical thinking and creativity which help to develop problem solving skills that will enable students face challenges of life.

Mathematics is one of the activity based subjects that requires students' hands and minds. This means that the subject requires knowledge construction and active participation on the part of both teachers and the learners. By the use of traditional teaching method, the teacher feels very secure and satisfied as they can follow it without much bothersome. In this method, no laboratory equipments or other materials are necessary. It is found to be very economical and it is suitable for the schools of our nation, where problem of shortage of resources is generally faced (Abei, 2020). By conventional teaching method, the teacher can cover lengthy syllabi within a short period of time. It can keep a logical sequence of subject properly, which does not lead to the wastage of time and money in any form in the teaching process. As a result of information provided through the use of conventional lecture method, students' level of motivation and confidence get boosted up to a considerable extent. Notwithstanding the numerous advantages of conventional lecture method of teaching, Heick (2021) called for an instructional approach that can use questions as extraordinary learning tools which can open minds, shift paradigms and force the uncomfortable but transformational cognitive dissonance that can help create thinkers during instructions.

Cognitive strategies are guides that suppor8t learners as they develop new internal procedures which are procedures that enable learners monitor and regulate cognitive activities, as well as perform high-level operations in scientific problem solving (Rosenshine, 2019). A learning process that is capable of maximizing learners' cognitive strategies in knowledge acquisition involves individual metacognition. The term metacognition refers to an individual's own awareness and consideration of cognitive processes and strategies (Orefor, 2016). Colette (2021) defined metacognition as the awareness or analysis of one's own learning or thinking processes and how to control the processes. It involves self-regulation and self-reflection of strengths, weaknesses and the types of strategies one create to address a situation or solve a problem. The strategies can be referred to as metacognitive strategies.

Metacognitive strategies, according to Walshe (2020) are sequential processes that one uses to control cognitive activities and to ensure that a cognitive goal has been met. The process helps to regulate and oversee learning, and consists of planning and monitoring cognitive activities, as well as checking the outcome of the activities and comparing cognitive outcome with internal or external standard. According to Drew (2019), metacognitive strategies are seen as effective tools which help learners to be consciously aware of what they have learnt and recognize situations in which they could be useful.

The use of metacognitive strategies as observed by Walshe (2020) is consistent with the tenets of constructivism. Constructivism takes learning as an active procedure during which students reconstruct knowledge. According to EduTech (2021) metacognitive instructional strategies are especially important because they affect acquisition, comprehension, retention and application of what is learned. Besides, Drew (2019) added that they affect learning efficiency, critical thinking, and problem solving. Teachers should therefore teach students cognitive processes and metacognitive strategies, to help them to retain what was learnt and become good problem solver. Some of Metacognitive instructional strategies as pointed out by EduTech (2021) include concept map, framing, advanced organizer, regulatory self questioning among others. The regulatory self questioning strategy is the aspect of metacognitive instructional strategy the present study focused on.

Regulatory self questioning strategy (RSQS2) is a strategy that enables students to monitor their learning and increase their ability to learn independently. Alutaybi and Alsowat (2020) defined regulatory self questioning as a process in which students ask and answer questions while learning. It is described as a situation in which learners can assume varying degrees of responsibility for their learning. Warger (2018) added that RSQS is a set of steps that students follow to generate, think about, predict, investigate and answer questions that satisfy curiosity about what is being learned. It is an ongoing process of asking question before, during and after learning. They are used by the learner to understand a lesson. The questions posed are based on clues that are found in the lesson or topic. The questions include; what do I already know about this topic? Have I solved a problem like this before? What do I need to know about this topic? What do I not know about this topic? These questions are generated to raise the curiosity of the learner's attention on investigating, understanding and connecting to the lesson. It is also, a strategy which involves the use of designed instructional packages that students can use to learn without or with minimum guidance of the teacher. The packages include a set of stimuli, provision for or of responses, feedback and test or self evaluation packages.

Regulatory checklist is a package that contains sets of metacognitive questions designed for learners to use during self questioning. The questions are grouped in three metacognitive categories; planning, monitoring and evaluation. It helps students during planning, monitoring and evaluating their learning. Regulatory checklist, according to Orefor (2016) is a useful tool that contains questions used to improve the regulation of cognition aspect of one's metacognition. It focuses on the monitoring of cognitive processes of an individual's problem solving and the functions are to help learners keep a continuous check on their progress (Ozgen, 2021). The questions are also designed to help students clarify problems and assess their existing knowledge and strategies when relevant.

Regulatory checklist as observed by Alutaybi and Alsowat (2020) as a package can assist students to instruct themselves while solving problems. It also facilitates learning by properly linking newly acquired knowledge with existing concept in the learner's schema. Using regulatory checklist during self questioning enhances in-depth understanding, retention and application of concept. Regulatory self questioning engages students in hands-on and minds–on learning activities which are keys to any meaningful instructional approach; increases students' eagerness to learn with its attendant increase in achievement.

Achievement is a degree of attainment of individuals in tasks or successful accomplishment of programmes to which they were efficiently exposed to. The specific type of achievement obtained from school is academic achievement. Adoga (2020) defined academic achievement as the attained ability or degree of competence in school tasks, usually measured by standardized test and expressed in grades or units based on norms derived from a wide sampling of pupils' achievement. It is the expected outcome of learning from students over a period of time. The outcome could be poor or good. Academic achievement in this study was measured using geometry achievement test. However, according to Okafor, Obialor&Osuafor (2020), opined that academic achievement may not primarily be an expression of learner's abilities but also a factor on gender view of themselves.

Gender has been defined as a cultural difference between women and men based on the biological division between male and female. It is a social or cultural construct, characteristics, behaviours and role which society ascribes to males and females (Collins, 2021). A study carried out by Akunne and Nwasor (2016) on students' Mathematics achievement based on stereotype threat in secondary schools

in Anambra State showed that, the Mathematics mean achievement scores of gender stereotype and non-gender stereotype of SS2 students significantly differed. A study by Bezzina (2017) on gender differences in Mathematics performance and in self-regulated learning (SRL) in 8Malta also showed that, girls performed significantly better than boys. These inconsistent results on gender related academic achievement generated the need for this study to determine the possible influence of gender on students' academic achievement and retention in geometry when taught using regulatory self questioning strategy (RSQS).

Purpose of the Study

The purpose of this study was to determine the effect of metacognitive instructional strategy on secondary school students' academic achievement in geometry in Idemili North Local Government Area of Anambra State, Nigeria. Specifically, the study sought to determine the;

1. difference between mean achievement sco8res of secondary school students taught geometry using regulatory self questioning strategy (RSQS) and that of those taught with conventional teaching strategy (CTS).
2. difference between the mean achievement scores of male and female secondary school students taught geometry using RSQS and CTS
3. interaction effect of teaching strategies and gender on secondary school students' academic achievement in geometry.

Research Questions

The following research questions guided the study;

1. What is the difference between the mean achievement scores of SS1 students taught geometry using regulatory self questioning strategy (RSQS) and that of those taught using conventional teaching strategy (CTS)?
2. What is the difference between the mean achievement scores of SS1 male and female students taught geometry using RSQS and CTS?

Hypotheses

The following null hypotheses were tested at 0.05 level of significance.

1. There is no significant difference between the mean achievement scores of SS1 students taught geometry using RSQS and those taught using CTS.
2. There is no significant difference between the mean achievement scores of male and female SS1 students taught geometry using RSQS and CTS.
3. There is no interaction effect of gender and instructional strategies on academic achievement of SS1 students in geometry.

Methods

The study employed quasi-experimental design. Specifically a pretest posttest non-equivalent control group design. The design was adopted in order not to disrupt the normal school activities and administration yet independent variables were manipulated in order to observe their effects on the dependent variables. The study was carried out in Idemili North Local Government Area (LGA) of Anambra State. The population of the study comprises of 3,363 (1671 males and 1692 females) senior secondary one (SS1) Mathematics students in government owned co-educational secondary schools in Idemili North Local Government Area. The sample size for this study was 98 SS1 students from two coeducational governments owned secondary schools in Idemili North LGA. Purposive sampling technique was used to select co-educational schools from the area. The choice of co-educational schools is that the school type provides classes where boys and girls will work together under the same teacher, with the same classroom condition.. Two schools out of seven co-educational schools were selected through purposive sampling. Purposive sampling was used to enable the researcher select schools with common characteristics such as; schools that are far apart and with experienced graduate Mathematics teachers. From the two schools selected, one intact class each was chosen out of all the SS1 streams by simple random sampling (balloting with replacement). One intact class in one of the sampled schools was assigned to experimental group while the other in another sampled school was randomly assigned to control group. This assignment into groups was done using a flip of the coin. The instrument for data collection was Achievement Test on Geometry (ATOG). The ATOG is made up of 50-item multiple choice objective questions. The items in the instrument were adapted and re-organized by the researcher from the 2008-2018 Senior Secondary Certificate Examination (SSCE) Mathematics past question papers. Each question item is made up of four (4) options A-D. The ATOG consists of two sections, A and B. Section A consists of the personal data of the respondents like; Gender and Class, and section B is the 50-item multiple choice questions. The test is designed to explore most of cognitive level such as knowledge (10 questions), comprehension (10 questions), application (20 questions) and analysis (10 questions). The instrument (ATOG) was validated by three experts, one from measurement and evaluation and two from science education. All the experts are in the Faculty of Education, Nnamdi Azikiwe University, Awka. The instrument (ATOG) was subjected to trial testing. The reliability was established using single administration method. A school in Idemili South LGA which is not in the research area was used and the Kuder – Richardson Formula 20 (K – R 20) was used to obtain the coefficient of internal consistency of the items which was found to be 0.80.

Before the commencement of the treatment on the experimental group, the trained class teachers in both the treatment school and control group school administered the pre-test (ATOG) to the treatment group and control group respectively. Data (pre-test scores) obtained was used to determine the extent of students' knowledge of geometry concept before the experiment. . However, the experimental group was taught using RSQS while the control group was taught using CTS. At the end of the treatment, posttests were administered using the same ATOG on students immediately after students in both groups have been taught for four weeks. Data collected were analysed using mean, standard deviation and analysis of covariance (ANCOVA) at 0.05 level of significance.

Results

Research Question One

What is the difference between the mean achievement scores of SS1 students taught geometry using regulatory self questioning strategy (RSQS) and that of those taught using conventional teaching strategy (CTS)?

Table 1: Pre-test and Post-test Mean Achievement Scores of students taught geometry using RSQS and CTS

		Pre-test		Post-test		Gained
Groups	**N**	**Mean**	**SD**	**Mean**	**SD**	**Mean**
Experimental	50	44.14	10.52	82.91	7.78	38.77
Control	48	44.02	10.74	72.29	8.81	28.27
Mean Difference		0.12		10.62		10.50

Results in table 1 reveals that the students taught geometry using RSQS had pre-test mean achievement score of 44.14 and post-test mean achievement score of 82.91 with gained mean achievement score of 38.77, while those in the control group taught with CTS has pre-test mean achievement score of 44.02 and post-test mean score of 72.29 with gained mean of 28.27. Students taught geometry using RSQS had a less spread of scores in the post-test (7.78) than those in CTS (8.81) indicating that students taught using RSQS had a more homogeneous score in their post-test. The difference between the mean gained achievement scores of the students in both groups 10.50 in favour of RSQS.

Research Question Two

What is the difference between the mean achievement scores of SS1 male and female students taught geometry using RSQS and CTS?

Table 2: Pre-test and Post-test Means and Standard Achievement Scores of Male and Female Students taught geometry using RSQS and CTS.

			Pre-test		Post-test		Gained
Gender		**N**	**Mean**	**SD**	**Mean**	**SD**	**Mean**
Male	RSQ8S	22	43.85	10.09	80.54	7.27	35.69
Female	RSQS	28	44.42	11.31	83.98	7.94	39.37
Mean Differe8nce			-0.57		-4.25		-3.68
Male	CTS	21	44.09	11.07	70.92	8.54	26.83
Female	CTS	27	43.91	10.42	73.59	8.99	29.68
Mean Difference			0.18		2.67		2.49

Table 3 reveals that the male students taught geometry using RSQS had pre-test mean achievement score of 43.85 and post-test mean achievement score of 80.54 with a gain in mean scores of 35.69, and female students taught geometry using RSQS had pre-test mean achievement score of 44.42 and post-test mean achievement score of 83.98 with a gain in mean scores of 39.37 while the male students taught geometry using CTS had pre-test mean achievement score of 44.09 and post-test mean achievement score of 70.92 with a gain in mean scores of 37.24, and female students taught geometry using CTS had pre-test mean achievement score of 43.91 and post-test mean achievement score of 73.59 with a gain in mean scores of 29.68. There was a higher spread of scores among the female students in the post-test (7.94) than

among males (7.27) in the experimental group, while in the control group female post-test (8.99) and male post-test (8.54) indicating in all that the male students had a more homogeneous score in the post-test. The difference between the mean gain achievement score of the male and female students is -3.68 for experimental group and 2.49 for control group in favour of the females.

Hypotheses

Hypothesis 1

There is no significant difference between the mean achievement scores of SS1 students taught geometry using RSQS and those taught using CTS.

Table 3:ANCOVA Test of Significance of Difference between the Mean Achievement Scores of Students taught geometry using RSQS and CTS

Source	Type III Sum of Squares	df	Mean Square	F	Sig
Corrected Model	9768.996[a]	4	2442.249	136.399	.001
Intercept	22753.633	1	22753.633	1270.788	.001
Pre-test	102.184	1	102.184	5.707	.019
Instruction	8717.233	1	8717.233	486.857	.001
Gender	1.115	1	1.115	.062	.803
Instruction*gender	.806	1	.806	.045	.832
Error	1665.178	93	17.905		
Total	118751.000	98			
Corrected Total	11434.173	97			

Table 3 reveals a significant mean effect of the instructional approaches on students' overall academic achievement in geometry; F (1, 93) = 486.857, P = 0.001 < 0.05. The null hypothesis was rejected. Therefore, there is a significant difference between the mean achievement scores of S8S1students taught geometry using regulatory self questioning strategy (RSQS) and those taught using conventional teaching strategy (CTS). This is in favour of RSQS group.

Hypothesis 2: There is no significant difference between the mean achievement scores of male and female SS1 students taught geometry using regulatory self questioning strategy and conventional teaching strategy. From Table 3, it reveals that F-value of .062 was obtained with level of significance of .803 which is greater than 0.05 set by the researcher. The null hypothesis was therefore accepted. This means that there is no significant difference between mean achievement scores of male and female SS1 students taught geometry using regulatory self questioning strategy and conventional teaching strategy.

Hypothesis 3: There is no interaction effect of gender and instructional strategies on academic achievement of SS1 students in geometry.

As shown in Table 3, it reveals that F-value of .045 was obtained with level of significance of .832 which is greater than 0.05 set by the researcher. The null hypothesis was therefore accepted. This means

that there is no interaction effect of gender and instructional strategies on academic achievement of SS1 students in geometry.

Discussion

The study revealed that the effect of regulatory self questioning strategy (RSQS) is significant when compared with the conventional teaching strategy (CTS). Those exposed to RSQS had higher gained mean score than those in the CTS group. This difference in achievement is further confirmed by the test of hypothesis 1 as reported in Table 3 of the study. Thus, there is a significant difference in mean achievement scores of students taught geometry using RSQS and those taught using CTS in favour of those in the experimental group (RSQS). This implies that RSQS was found to be effective. The positive effect of regulatory self questioning strategy can be attributed to planning, monitoring and evaluation. The use of regulatory self questioning strategy provides link from known to unknown through evaluative and assertive questions.

Regulatory self questioning strategy creates a lot of experience for the students enabling them to properly understand the concepts taught, thus improving achievement. This is in-line with the findings of Free (2021), Orefor (2016) and Ojo (2017) who found out that those students exposed to regulatory self questioning strategy achieved significantly higher than those exposed to conventional teaching strategy. The findings is also consistent with findings of Ezeji (2018) in Physics which revealed that regulatory self questioning strategy improved students achievement more than conventional teaching strategy, since the students share their wealth of ideas through classroom discourse, engagement and knowledge construct by themselves.

The study revealed that the effect of regulatory self questioning strategy (RSQS) is not significant between male and female students' achievement in geometry. The non-difference in achievement of male and female students is further confirmed by the test of hypothesis 2 Table 3 of the study. The findings of the study is in line with that of Akaeze and Okigbo (2021) who reported that metacognitive strategy has no significant effect on achievement of male and female students taught algebra using metacognitive reading strategy when compared to students taught with conventional teaching strategy.

The study showed that there was no significant difference in the mean achievement scores of students taught geometry using regulatory self questioning strategy. This finding of the study is because the regulatory self questioning strategy of instruction uniformly affected the students. Since every student irrespective of their gender participated in the activities, their achievements were equally affected, although the female students with a gained mean score of (39.37) performed better than the male students with a gained mean score of (35.69), but this was not significant. Therefore the effectiveness of RSQS on female secondary school students' achievement in geometry does not differ significantly when compared with that of the male students.

The significant increase in the achievement of both male and female students in the experimental group is attributed to the fact that RSQS is learner-centred with cognitive activities that appealed to both gender. Regulatory self questioning strategy is not gender biased. The result agrees with that of Okeke and Okigbo (2021), Ojo (2017), Akunne and Nwasor (2016) that there is no significant difference in the achievement of students with respect to gender. The interaction effects of instructional strategy and gender on students' achievement in geometry is also not significant.

Conclusion

The study concluded that the adoption of regulatory self questioning strategy (RSQS) is an effective way of improving students' achieve8ments in geometry. Through this means, students will understand the learning materials more irrespective of their gender.

Recommendations

The following recommendations were made in the light of the findings of this study:

1. Mathematics teachers should adopt RSQS while planning their lessons to enhance students' interaction with each other and the learning materials to facilitate effective learning and retention.
2. Curriculum planners and textbooks writers should include the use of RSQS while reviewing the curriculum and textbooks.
3. The Science Teachers Association of Nigeria in collaboration with the government should organize seminars and workshops to train teachers on how to use RSQS in teaching and learning of Mathematics and other science subjects.
4. The government, especially the Ministry of Education should introduce RSQS into the school curriculum for Mathematics instruction.

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