EFFECTS OF METACOGNITION ON STUDENT'S ACADEMIC ACHIEVEMENT AND RETENTION LEVEL IN SCIENCE CURRICULUM CONTENT

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ABSTRACT

The study focused on enhancing academic achievement and retention level of science students through metacognitive strategy in Delta Central Senatorial District, Nigeria, West Africa. The quasi-experimental design was used, specifically the non-equivalent control group pre-test post-test design using intact classes. The population of the study was 30,372 students in Delta Central Senatorial District. A sample size of 221 SSII science students was used. The instruments used for the study were the Science Achievement Test (SAT) and Metacognitive Awareness Reading Strategy Inventory (MARSI), which were adequately validated, with a reliability coefficient of 0.80 and 0.70 respectively. Data were collected by administering the SAT as pre-test and post-test and MARSI to categorize students into high and low metacognitive level. The data obtained were analysed with mean, standard deviation and t-test. A significant effect of metacognition was observed on the academic achievements of science student; a significant difference in the retention level of students exposed to metacognition and lecture teaching strategies; a significant difference between students with high metacognitive awareness and those with low metacognitive awareness; a non-significant difference between male and female students exposed to metacognitive strategy. Based on the results of the findings, it was concluded that metacognition is a better option in teaching and learning science. The study recommended that teachers should adopt the use of metacognitive strategy in the teaching and learning Science Curriculum Content in schools among others.

Keywords

academic achievement, metacognitive level, retention level, science students

Introduction

The function science plays in technological innovative development across developed and developing nations globally has long been realized (Heeks and Stanforth, 2015). The study and practice of science is felt in all part of the world including a developing nation like Nigeria which has been in high demand for scientific skills and manpower. Based on the importance of science, the government, through the National University Commission (NUC, 2002) has established the 60% science and 40% education allocation for enrolment into higher institutions in Nigeria. Ahmed *et al.* (2012) observed that evidence exists that science is not only tools but also a vehicle for all round development of any nation. Hence the development of science determines to a high level the standard of living of its citizens. Science provides a body of knowledge for use in addressing various form of human material and environmental problems hence its teaching is geared toward skills acquisition. Teaching is a complex activity, as the knowledge of the subject matter influences students' performance. A major pillar of science education is science teaching for conceptual assimilation and comprehension (Baumert *et al.,* 2010).

Understanding the nature of science as it relates to scientific inquiring is the motive behind science and science education in general. The study of science as a "way of knowing" and a "way of doing" gives a better understanding of the world (Carter, 2007). Science curriculum at all levels must be global and most address the millennium development goals if Nigeria must not be left behind in the globalizing world. Hence, according to the secondary school curriculum for science, the specific objective to be achieved by science curriculum include: development of creativity in learners; scientific and technological literacy improvement, preparation of citizens towards active cultural contribution, and inculcation of high level of scientific intuition in learners (National Policy on Education, 2004). These objectives are achieved through effective and adequate science instructions. This emphasizes the need to use quality instructional strategy that will enhance the achievement of the objectives of teaching science at the secondary school level. Unfortunately, science teachers adopt instructional strategies such as the conventional lecture method that are mainly teacher directed and do not encourage deeper students' involvement (Ajaja,2005).Therefore, a poor science foundation at the secondary school level will jeopardize any effort to enhance achievement in science and production of scientists and technologists needed for advancement. Hence, it is important to adopt instructional strategies that will encourage deeper student involvement.

However, with the increase on emphasis in lesson clarity, promoting self-activity, stimulating interest, and curiosity, coupled with high rates of retention, and life-long learning, there is need to explore other innovative instructional strategies for teaching science different from the lecture method. Enhancing academic achievement and retention level of science students through metacognitive strategy is the major purpose of this study. Specifically, the study:

- Compared the relative effectiveness of two instructional strategies; the metacognitive and the lecture strategies.
- Find out if there is any difference in the retention level of science students exposed to metacognitive strategy.
- Find out if there is any difference in achievement test scores between male and female students exposed to metacognitive strategy.
- Find out if there is any difference in achievement test scores between students with high metacognitive awareness and those with low metacognitive awareness.

To guide the study, the following research questions were raised:

- Is there any difference in achievement test score between students exposed to metacognitive and lecture strategies?
- Is there any difference in the retention level of students exposed to metacognitive as the lecture strategy?
- Is there any difference in science student's achievement test scores between male and female students exposed to metacognitive strategy?
- Is there any difference in science achievement scores between students with high metacognitive awareness and those with low metacognitive awareness?

The following hypotheses was formulated and tested at 0.05 level of significance:

- There is no significant difference in achievement test scores between students exposed to metacognitive and lecture strategies.
- There is no significant difference in the retention level of students exposed to metacognitive and lecture strategies.
- There is no significant difference in science achievement test scores between male and female students exposed to metacognitive and lecture strategies.
- There is no significant difference in science achievement test score, between students with high metacognitive awareness and those with low metacognitive awareness.

The outcome of this study will be of great benefit to stakeholders which include students, teachers, curriculum planner, school administration, educational institutions as well as future researchers. Science teacher may make use of the findings of this study to redirect their teaching strategies on science concepts to enhance academic achievement. The outcome of this study may help students become aware of their thought processes, improve their problem-solving skills and help them become independent, autonomous thereby improving their academic performance. School administrators and educational institution may find the result of this study useful to improve the metacognitive abilities of students. The findings of this study may help curriculum planners in ensuring that they plan and develop curriculum with consideration of student's metacognitive awareness. It will also aid curriculum developers in reviewing the senior secondary school science curriculum. To future researchers, the finding of this study will serve as a reference material. Finally, this study may also contribute generally to the stock of knowledge in science education because knowledge is the basis upon which any discipline grows and the scientific process is the most reliable means for the building of scientific knowledge.

Existing Literature

The concept of metacognition is credited to an American Developmental Psychologist John Hurley Flavell (1976) in his article or publication metacognition aspects of problem solving. Metacognition is the analysis of the process of thinking and learning by one's self (Merriam-Webster, 2012). It is the ability to think about and control one's own learning and mental processes. Kuhn and Dean 2014, defined metacognition as the awareness and management of one's own thought while Martinez, (2006) sees metacognition as the monitoring and control of thought. According to Aswegen, Swart and Oswald (2019), metacognition entails awareness of one's thought patterns and using such awareness to moderate actions and behaviours. The National Research Council (2000) stated that metacognition also includes self-regulation –one's ability to organize learning; plan for, keep track on, and correct possible errors when appropriate, all of which are necessary for intentional learning. Students keep track on their leaning process through questioning oneself with words like "what am I doing now" Is it getting me anywhere?" What could I possibly be doing instead? General metacognitive level help students in unproductive approaches (Perkins & Solomon, 1989 as cited in Kimberly, 2012). Metacognition can be classified into two main components

- Metacognitive knowledge
- Metacognitive regulation

Several researchers namely Kuhn and Dean (2004) and Schraw, Crippen and Hartley (2006) used the concept of declarative, procedural and conditional knowledge to distinguish metacognitive knowledge types. Declarative knowledge refers to epistemological understanding or the students understanding of thinking and knowing in general. It can also be portrayed as knowledge about oneself as a teacher and what factors might influence one's performance. Procedure knowledge involves awareness and management of cognition including knowledge about strategies while conditional knowledge is knowledge of why and when to use a given strategy. Metacognitive regulation involves three regulatory skills or activities of planning, monitoring and evaluating. Planning involves identifying and choosing appropriate strategies and resources. Monitoring involves being aware of comprehension and task performance while evaluating involves appraisal of judgment of outcomes and the effectiveness of the regulation process. Metacognition is of great importance in teaching and learning of science. It helps teachers convey the responsibility to students to watch their learning. This helps the students to become self-directed learners and take control of their learning. Metacognition helps students develops useful problem-solving strategies or skill, unlock their brains amazing power and take control of their learning (Wilson & Conyer, 2016). Success of metacognition affects students' academic performance in science as well as their ability to communicate what they know about a particular problem to instructor, which is crucial to the learning process (Coutinho, 2008). Enhancement of metacognition enables student respond better to issues and retrieve stored information (Howe, 2019). In this study metacognition will be measured as metacognitive awareness using Metacognitive Awareness Reading Strategies Inventory (MARSI) by Mokhtarr and Reichard, (2002). MARSI is a self-report questionnaire containing 30different items used in rating frequency of essential metacognitive strategy towards science. The items are arranged in three scales viz; reading, problem solving, and support strategies.

Theoretical Framework

Flavell theory of metacognition is adopted for the study. Using the met memory term with regards to the ability of an individual to keep track on and manage input, search, store and retrieve contents, Flavell validated the fact that metacognition include regulation and monitoring aspects. The implication is that learner should be able to monitor and regulate learning process for better outcome. Flavell further stated three phases which children undergo in the process of storage and recall of information, viz; learning to recognize events where information which could be useful in future times are consciously stored, the child is keen on preserving and storing current information necessary for problem-solving as well as making it available as at when needed. It also enables the child to embark on systematic search for useful information which are capable of solving future problems. Flavell theory of metacognition thus emphasized metacognitive awareness and metacognitive learning strategies. Metacognitive awareness includes the student knowledge and beliefs about him/herself as a thinker or learner and what he/she believes about other people thinking processes. These form the basis upon which the study is linger on.

Methodology

Study Method

This study adopts a non-randomised quasi-experimental design, using an intact class pre and post-tests approach. The study employed a 2x2x3 factorial design which consist of two instructional strategies metacognitive and lecture method which formed the independent variables, sex (Male and Female) and repeated testing. The intact classes were randomly assigned to experimental and control groups respectively.

Population

The population consisted of all Senior Secondary School Class II Science Students consisting of 30,372 from Delta Central Senatorial District of Delta State, Nigeria. Five Public Secondary Schools were randomly sampled from five Local Government Areas which were used for the study. The sampled schools were obtained by simple balloting through replacement and withdrawn technique.

Study Sample

The sample consisted of two hundred and twenty-one made up of one hundred and nine (109) which form the lecture strategy (control group) and one hundred and twelve (112) with metacognitive strategy consisting of 50 males and 62 females.

Study Tools

The research instruments for the study were the Science Achievement Test (SAT) and Metacognitive Awareness Reading Strategy Inventory (MARSI). SAT contained 50 multiple-choice objective questions while MARSI contained 30 items to be read by science students about what they do when they read science materials. The aim of MARSI was to categorize students into high and low metacognition (Metacognitive awareness). The validity of SAT and MARSI were ascertained by Measurement and Evaluation and Science Education experts, Delta State University, Abraka. Based on constructive criticism and useful suggestions, necessary collection of the instrument was made and adopted for the study. SAT and MARSI were subjected to reliability test to groups of 40 science students outside the sample area. The data was subjected to statistical analysis using the Pearson Product Moment Correlation and Cronbach Alpha which yielded coefficient of 0.80 and 0.70 respectively. The high reliability value suggested that the instruments were reliable and could be used to collect data for the study.

Treatment Procedure

Official permission was duly obtained from the heads of the five schools used in the study while the science teacher served as research instructors. The instructors were trained on how to use the metacognitive learning strategy in teaching science and orientation on administration of MARSI questionnaire. At the end of the orientation, the instructor were given copies of the instructional packages comprising four weeks instructional unit a comprehensive lesson plan and instructional materials. MARSI was administered to all the sampled students. After four (4) weeks off treatment the post-test was administered and scores recorded. Three weeks after the completion of instruction a follow-up test was also administered. The statistics used for analysis include the mean, standard deviation and t-test which was tested at 0.05 level of significance.

Results

Table 1 shows a pre-test mean achievement score of 30.21 and standard deviation of 6.23 for Metacognitive strategy and a protest mean achievement score of 25.66 and standard deviation of 7.61 for lecture strategy. For the post-test, the metacognitive strategy has a higher mean of 63.14 with a standard deviation of 13.64 while lecture strategy had a mean score of 57.42 with standard deviation of 12.31. This implies that metacognitive strategy has effect on students' academic achievement in science since there was a mean gain of 46.67 as against 41.54. Table 2 showed that science achievement score significantly differs between students subjected to metacognitive strategy and those in lecture strategy with p-value of less than 0.05 level of significance (t=27.95, P<0.05). The null hypothesis is therefore rejected. Table 3 shows that male recorded mean achievement score of 20.45±7.21and 23.34±8.46 for female in the pre-test assessment. This implies that the two groups were originally almost at the same level of achievement. Mean score achievement for post-test was 63.24±14.01 for male and 60.11±12.52 for female respectively. The male students had a slightly higher mean gain of 42.27 as compared to 38.72 for the female. Table 4 showed that no significant difference exist between mean achievement scores of male and female students in science when exposed to metacognitive strategy with P-value of 0.379 greater than 0.05 level of significance at t= 0.572, p (0.379)> 0.05.

Table 1 Mean and Standard Deviation of Pre-test and Post-test Achievement scores among science students exposed to Metacognitive and lecture strategies.

Group	Pre-test			Post-test		
	N	Mean	SD	Mean	SD	Mean Gain
Metacognitive	112	30.21	6.23	63.14	13.64	46.67
Lecture	109	25.66	7.61	57.42	12.31	41.54

Table 2 t-test analysis of the difference in science achievement between students exposed to metacognitive and lecture strategies.

Group	N	$\bar{x}$	SD	df	t-cal	P
Metacognitive	112	63.14	13.64			
Lecture	109	57.42	12.51	102	27.95	.000

Table 3 Mean and standard deviation of pre-test and post-test mean achievement scores of Male and Female students exposed to metacognitive strategy

Group	Pre-test			Post-test		
	N	Mean	SD	Mean	SD	Mean Gain
Male	50	20.45	7.21	63.24	14.01	42.27
Female	62	23.34	8.46	60.11	12.52	38.64

Table 4 Analysis of t-test for difference in achievement scores of male and female students exposed to metacognitive strategy.

Gender	N	$\bar{x}$	SD	df	t-cal	P
Male	50	63.24	14.01	101	0.872	0.379
Female	62	60.11	12.52			

Table 5 showed that students exposed to metacognitive strategy had a mean score of 58.3 with a standard deviation of 8.5 in the follow up test while students in the lecture group had a mean of 51.3 with a standard deviation of 8.4.This indicated that students exposed to metacognitive strategy retained more of the learnt materials than those in the lecture group. Table 6 showed that students who have high metacognitive awareness had a mean score of 60.4 with a standard deviation of 8.92 while those with low metacognitive awareness had a mean score of 41.2 with a standard deviation of 6.08. This indicates that there is a difference in favour of those with high metacognitive awareness. Table 7 showed a significant difference recorded in science achievement scores of students with high metacognitive awareness and those with low metacognitive awareness with p-value 0.000 less than 0.005 level of significance (t= 24.21, P<0.05).

Table 5 Mean and standard deviation of retention level of students exposed to metacognitive and lecture strategies in the follow-up test

Group	N	$\bar{x}$	SD
Metacognitive	112	58.3	12.2
Lecture	109	51.3	8.4

Table 6 Mean and standard deviation between students with high metacognitive awareness and those with low metacognitive awareness

Metacognitive Awareness	N	$\bar{x}$	SD
Low	101	41.2	6.08
High	120	60.4	8.92

Table 7 t-test analysis of the difference in achievement scores of students with high metacognitive awareness and those with low metacognitive awareness.

Group	N	$\bar{x}$	SD	df	t-cal	P
Metacognitive	120	60.4	8.92	101	24.21	.000
Lecture	101	41.2	6.08			

Discussion

The study focused on enhancing academic achievement and retention level of students through metacognitive teaching strategy. The study is quite significant and timely considering the persistent poor performance of students in science, which led to the search for alternative strategies on which metacognitive strategy was adopted. One major finding of this study is that students exposed to metacognitive strategy performed better than those exposed to lecture strategy. This indicate that the metacognitive strategy was more effective in the teaching and learning of science than the lecture method which corroborates with Oyovwi (2019) in his study of cognitive restructuring. This finding is also in line with Nzewi and Ibeneme (2011) and Narang and Saini (2012). Their work proves that metacognition correlates significantly with students' academic performance. There was a significant difference in science achievement score between students with high metacognitive awareness and those with low metacognitive awareness. This finding indicated that metacognitive awareness is very important in the teaching and learning of science in schools. This is in agreement with Weilson and Conyer (2016), who observed that students who demonstrate a wide range of metacognitive skills perform better in examination and complete work more effectively. The finding also agrees with Oyovwi (2013) that high ability students performed better that low ability students.

Furthermore, there was no significant difference in science achievement between male and female students. By implication, it means that metacognitive strategy does not discriminate between male and female students in science achievement which corroborates with the view of Oyovwi (2020), who showed that innovative strategies such as metacognitive and outdoor school activities strategies are not gender bias. This is also in agreement with Coutinho (2008) and Dunning and Kruger (2003). They showed in their studies that metacognition is an important predictor of academic performance in science as well as their ability to communicate what they know about a particular problem, and it is not sex bias. Finally, there was also a significant difference in the retention level of students exposed to metacognitive strategy and those in the lecture group. The implication is that students exposed to metacognitive strategy were able to retain more of the content materials.

Metacognitive ability enables students to utilize their cognitive abilities, taking control of their learning process thereby enhancing retention. The findings correlate with that of Oyovwi (2020).

Conclusion

This study exposed the effectiveness of adopting metacognitive learning strategy in the teaching-learning process of Science Curriculum in secondary schools. Also, the level of metacognitive awareness determines student's achievement in science and so it should be encouraged. Metacognitive strategy is sex friendly. It does not discriminate. The implication is that both male and female benefits maximally in science classes. With regards to the study, it is recommended that:

- Science teachers adopt metacognitive strategy in teaching science it will ensure students active involvement easy comprehension of concept and high retention of learnt material.
- Government and educational stakeholders organize training for serving teachers on how to effectively implement metacognitive strategy in actual classroom teaching.

- Other policy makers in the Ministry of Education and principals of secondary schools should lend full support to make other strategy a reality in schools.
- Curriculum planner, developer and science educator should take cognizance of this method when reviewing the curriculum in order to have an adequate spread in imparting relevant skills for students to engage in metacognition.

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