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Metacognitive Teaching Strategies on Secondary School Students Academic Performance

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ABSTRACT
The study was undertaken to examine the effect of metacognitive teaching strategies on secondary school students' performance in chemistry. The study adopted pretest post test quasi experimental design. Three hundred and sixty senior secondary school II (SSII) chemistry students were drawn from three secondary school in Obio/Akpor Local Government of Rivers State Nigeria. Three research questions and three hypotheses were posed for the study. The instrument for data collection was a twenty five-item multiple choice chemistry achievement test (CAT) developed by the researcher. Students were divided into two experimental groups and one control group. Students in the experimental groups were subjected to treatment using thinking-aloud and self assessment metacognitive teaching strategies while students in the control group were taught with conventional method. Mean, standard deviation, t-test and ANCOVA were used for data analysis. The results showed that students taught with thinking-aloud metacognitive strategies performed better in chemistry achievement test followed by self assessment metacognitive strategy than the conventional strategy. It was concluded that metacognitive teaching strategy such as thinking-aloud and self assessment if effectively utilized and applied by teachers in the instructional delivery in chemistry could significantly improve the performance of students.

Keywords: *Metacogntion, Metacognitive teaching strategies, Performance*

I. INTRODUCTION

Chemistry is a central science and it benefits to humans cannot be overemphasized. Chemistry has great impacts in our lives. Chemists have synthesized new fiber, medicine, fertilizer, pesticides and structural materials (Brown, Lemay, Bursten, Murphy, Woodward&Stolzfus, 2014). These among others are the reasons why the Federal Republic of Nigeria (FRN,2014) gave it a place as a core subject and non vocational elective. The importance of chemistry is in line with the goals of secondary education in Nigeria which emphasized useful living within the society (FRN, 2014). In spite of the recognition given to chemistry, it is evident that students' still show negative attitude towards chemistry thereby leading to poor performance and low enrolment (Chinda, 2009).

Academic achievement of students in science subjects generally had witnessed a deplorable trend in the past decades. Nigerian secondary school students' performance in science has been poor and unimpressive over the years (Njoku 2007; Chinda, 2009). Ogunleye (2000) attributes the poor performance in science in senior secondary school certificate on students' inability to pass integrated science at Junior Secondary school (J.S.S.) level before been promoted to senior secondary school (S.S.S.) and to embark on serious study of science subjects. This may have adverse effect on the study of science subjects at SSS level.

Chinda (2009) attributed the poor performance of students in science to lack of commitment to academics. Students see the science subject especially chemistry and physics as hard subjects which discouraged their interest for science. In line with the setback in science is the dearth in science resources (Obi &Idoha, 2013). They asserted that for students to achieve better in chemistry ,instructional materials should be use in the teaching of chemistry because chemistry requires real objects and activities / experiment that can convert topics that seem imaginary to concrete for students understanding.

The WAEC Chief Examiners report of May/June, (2014), stated that the performance of candidates in chemistry were affected by the following weaknesses

- non adherence to rubrics
- poor communication skills:
- lack of understanding of the demands of the questions;
- poor mathematical skills in calculating moles, molar masses and percentage purity;

- inability of candidates to draw correct structure of organic compounds and naming them using the IUPAC nomenclature;
- Inability to properly define terms such as standard electrode potential, nuclear fission;
- inability to balance chemical equation;
- inability to distinguish between acid salts and normal salts;
- Poor knowledge of concept of electrolysis

In order to improve performance in chemistry the onus lies on the part of the teacher to use instructional strategies that will enhance performance. Most chemistry teachers believe that scientific investigation must be done in the laboratory, even when the laboratories are not readily available, science teachers employ traditional method and do not facilitate real learning of science subjects (chemistry inclusive). Teaching methods such as lecture, memorization, text – book reading etc do not encourage student's activities such as discussion, manipulating objects, experimentation, and creative thinking which are necessary for real science learning.

FRN (2014) emphases activity based and child centered learning. Nevertheless most chemistry lessons are still taught with this conventional method. Teaching methods such as inquiry, project, demonstration, problem solving, field trips, cooperative or group learning, excursion remedial, laboratory and guided discussion and the use of audiovisual materials have been recommended for the teaching of science in school (Adedoyin, 2000; Ajewole, 2001).

Experiential or "hand on" learning is fast replacing or supplementing the traditional chalk talks" methods of teaching (Ikiroma&Chinda, 2013). Experiential learning increases retention, motivates students to learn and encourage group cooperation. In a study conducted by Ikiroma&Chinda (2013) on the impact of inquiry, project, lecture and demonstration teaching methods on senior secondary student's achievement in separation of mixture practical test the project method produced significantly better performance in chemistry achievement test. Proving that project method is a more effective instructional strategy for teaching chemistry in secondary school.

According to Okoronka and Wada (2013) the most important factor which had significant effect on students academic achievement was the instructional strategy adopted. Okoronka and Wada recommended that analogy instructional strategy should be adopted by science teachers to teach some abstract or difficulty concepts instead of the conventional lecture method as a measure to improve achievement. For better performance in chemistry the teacher should use instructional strategies that will enhance problem solving skills and creativity. This can only be achieved through the use of metacognitive teaching strategies. Metacognition refers to cognitive control and monitoring of all sorts of cognitive processes like perception action, memory reasoning (Wikipedia, 2015). It can be further defined as what we know about our cognitive process and how we use these processes in order to learn and remember (Ormrod, 2004). Metacognition is a regulatory system that helps a person understand and control his or her own cognitive performance. Flavell referred to metacognition as one's knowledge concerning one's own cognitive processes and products or anything related to them. Metacognition is simply thinking about thinking. This is a higher level of cognition given the label metacognition by American developmental psychologist John Flavell (Flavell, 1976). Metacognition has two main components metacognitive knowledge and regulation.

Metacognitive knowledge is described as what we know about our own cognitive process. It is knowledge about what factors act and interact in what way to affect the course and outcome of cognitive enterprises (Flavell, 1979). Three categories of metacognitive knowledge are person, task and strategy. The metacognitive knowledge person refers to the individual involved in the cognitive process. Task metacognitive knowledge refers to information, skills, and competencies abilities available to a person. The strategy metacognitive knowledge category includes knowledge of effective strategies that can be acquired in achieving various goals and in various sorts of cognitive undertakings (Rahman, 2011). Metacognitive regulationinvolves setting goals and planning; monitoring and controlling learning; and evaluating one's own regulation (assessing results and strategies used). Metacognitive strategies according to Novak (1987) are strategies that empower the learner to take charge of his/her own learning in a highly meaningful fashion. They are skills that the teacher and the learner use to achieve desired goals. The learner uses these strategies to regulate his cognitive process. There are several types of metacognitive strategies; there is no exact number of them. Many strategies have been identified by various researchers. In 1997, Ashman and Conway reported that various techniques can be used to improve metacognition and the techniques included direct explanation, scaffolded instruction, cognitive coaching and cooperative learning. Rivers (2001) categories metacognitive strategies into two self assessment and self management. Gamma (2004) divided metacognitive strategies into seven namely: Reflective questions and prompts, metacognitive scaffolding, modeling, self questioning, think aloud and self explanations, self assessment and graphic organizers.

In another development Zhao, Wardeska, McGuire and Cook (2014) found that students taught metacognition in the classroom preformed better on the last exam as opposed to students who were taught using traditional lecture, however metacognitive strategies can be combined with other instructional strategies to enhance

meaningful learning. This paper seeks to use the self assessment and thinking aloud as metacognitive strategies for teaching chemistry.

Thinking aloud is a metacognitive strategy in which the teachers help the students to organize and enhance their thought while they are working especially during problem solving. In thinking aloud students need to think critically and verbalized their taught. In the thinking aloud metacognitive strategy students are invited to describe their thinking (goals, plans, strategies means to be used etc) and explain their choices to produce more thinking. In think aloud strategy students are encouraged to examine their current thinking by asking the following questions e.g. what do I already know about this topic that could guide my learning? Is there any relationship between this topic and my knowledge from other subjects? How do I tackle this problem if it appears in my test or final examination?

Thinking aloud can be done in pairs to enhance cooperative and collaborating learning among students. One is a problem solver who verbalized their thought process and the other is a listener who probes the problem solver with question to get them to clarify their thinking. The listener does not help the problem solver they only ask question about the problem solving methods. A study conducted by Pate (2009) on the effect of think aloud pair problem solving on secondary level students' performance in technical education courses shows that there was significant difference with students taught with think aloud strategies.

Jeon, Huffman and Noh (2005) observed in their investigation on the effectiveness of thinking – aloud pair problem solving (TAPPS) in improving problem solving performance of high school chemistry students.It was observed that students in both the individual and TAPPS group performed better in problem solving compared to the control group. They found out that students in the individual and TAPPS group performed better in recalling the related law and mathematical execution. The student in TAPPS group performed better than others in conceptual knowledge. Hatizah, Kani and Shahrimm(2015) in a study of applying the thinking aloud pair problem solving in mathematics lesson reveals a significant improvement in students problem solving behaviors especially in understanding the problem. Beneham (2009) using the talking aloud pair problem solving to enhance students performance in productive software course, the result revealed that students who followed the TAPPS process performed better. Self assessment on the other hand, means that students who observe and evaluate their performance accurately may react appropriately by keeping and changing their strategies to achieve the learning goals. Self assessment is personal reflection during and after learning experiences. It encourages learners to critically analyze their own assumptions and how this may influence their learning (Malamed, 2015). Metacognitive self assessment is a self monitoring approach in which learners get involved in the assessment of their own progress and deficiencies in the process of learning (Rivers, 2001).

According to Schunk (1996) self assessment is simply judging the quality of one's work. It is the process of assessing the quality of work done based on evidence and explicit criteria. Self assessment is a goal oriented process. It involves the learner evaluating him or herself before the summative evaluation by the teacher. Self assessment is a learner oriented strategy to achieve success. It involves the learner taking his destiny in his own hands. The learner uses self assessment to help understand the lesson by asking relevant questions and using the answer to question to tackle the class test or examination. MC Millan& Hearn (2008) identify three steps necessary in self assessment process. The steps are self monitoring, self evaluation and implementing correction. In self monitoring, a student addresses "Do I know this"? Self evaluation, a student asks "How well do I know this compared to what is expected of me"? The student implements the correction by enacting the answer to the question "what do I do to improve and meet my expectation"? (Felkamp2013:5) Lew, Alwis and Schmit (2010) asserted that effective learner use the answer to these questions to recognized their strength and weakness and to direct their studying. Felkamp (2013) found out that self assessment is an important skill students need to develop to be effective learners and self assessment enhances performance in chemistry among High School Students. Oluwotosin and Bamidele (2014) revealed that there is a positive correlation between students self concept and their academic achievement in chemistry. Therefore the purpose of this study is to access the effects of thinking – aloud and self – assessment metacognitive teaching strategies on secondary school students performance in chemistry.

Research questions

The following research questions guided the study

1. What is the effect of thinking aloud metacognitive strategy on students' performance in chemistry?
2. How does the performance of students in thinking aloud metacognitive strategy differ from those in the self assessment metacognitive strategy in chemistry?
3. What are the effects of thinking aloud, self assessment and conventional strategies on students' performance in chemistry?

Hypotheses

To answer the research questions of the study the following hypotheses were formulated and tested at 0.05 levels of significance

1. There is no significant difference between the mean pretest and post test scores of students taught with thinking aloud metacognitive teaching strategy.
2. There is no significant difference in performance in chemistry between thinking aloud and self assessment group.
3. There is no significant difference in performance in chemistry among students using thinking – aloud, self assessment and conventional strategies.

II. METHODOLOGY

The design for the study was a two group pretest post test control group quasi experimental design. The population of this study consists of all senior secondary school two (SSII) students in Rivers State. Purposive sampling procedure was used to select three schools in Obio/Akpor Local Government Area of Rivers State. Two experimental group and one control group were randomly assigned to the various method of teaching. Experimental group one the think-aloudmetacognitive strategies and consist of 140 students, experimental group two is self assessment consist of 120 students. The control group is the conventional method made up of 100 students. This gave a sample of 360 students. The instrument for data collection was chemistry achievement test (CAT) developed by the researcher based on the chemistry curriculum; the test was made up 25 multiple choice objective tests. It was designed to covertopic on stereochemistry. The test was validated by deriving the CAT from the National school chemistry curriculum given for secondary schools in combination with West African Examination Council (WAEC) syllabus and with the aid of chemistry past question of West African Examinations Council. The CAT was administered to sixty (60) students in Emohua Local Government Area that is not part of the study This was done to determine the reliability of the test instrument via Cronbach alpha which gave an index of 0.82. The pretest/post test method of data collection was used before and after intervention for three weeks using the same chemistry achievement test. Data analyses were done using mean, standard deviation t-test and ANCOVA.

III. RESULTS

Research Question 1

What is the effect of thinking aloud metacognitive strategy on students' performance in chemistry?

Hypothesis 1

There is no significant difference between the mean pretest and post test scores of students taught with thinking aloud metacognitive teaching strategy.

Table 1: t – test analysis of students mean pre-test and post test scores on Thinking aloud metacognitive teaching strategy

Variable	N	Mean	SD	t	df	sig	Decision
Pre test	140	6.60	2.259	-50.726*	139	0.000	sig
Post test	140	16.82	2.885				

Significant, P< 0.05 level of significance

The mean pretest value is 6.60 and the mean post test value is 16.82 shows difference between pretest score and post test score. On statistical testing difference was found to be significantly different as shown in the $t_{(139)} = -50.726$, $P<0.05$. Therefore the null hypothesis which states that there is no significant difference between mean pretest and post test scores of students taught with thinking aloud metacognitive teaching strategy is rejected. This implies that subjecting the students to thinking aloud metacognitive strategy enhances performance.

Research question 2

How does the performance of students in thinking aloud metacognitive strategy differ from those in the self assessment metacognitive strategy in chemistry?

Hypothesis 2

There is no significant difference in performance in chemistry between thinking aloud and self assessment group.

Table 2: Summary of ANCOVA analysis of thinking aloud (TA) and self assessment (SA) metacognitive teaching strategies.

Groups	N	Mean	SD
TA	140	16.82	2.885
SA	120	16.54	3.167

Source	Type III Sum Of Squares	df	Mean square	F	Sig.	Partial Eta Squared
Pretest TASA	1017.728	1	1017.728	196.275	.000	.433
Group TASA	689.792	1	689.792	133.031*	.000	.341
Error	1332.600	275	5.185			
Total	74800.000	260				
Corrected Total	2355.385	259				

a. R Square =.434(Adjusted R Square=.430)

Table 2 shows that the thinking aloud has a mean score of 16.82 while the self assessment has a mean score of 16.54. There is a slight difference between the means of thinking-aloud and self assessment groups, however the mean difference is statistically significant. This is shown by the obtained F-value of 133.031 which is significant at 0.000. The null hypothesis of no significant difference in performance in chemistry between thinking aloud and self assessment group is rejected.

Research question 3
What are the effects of thinking-aloud, self assessment and conventional strategies on students' performance in chemistry?

Hypothesis 3
There is significant difference in performance in chemistry among students using thinking – aloud, self assessment and conventional strategies.

Table 3: Summary of ANCOVA analysis of thinking aloud (TA), self assessment (SA) and conventional (CO) meta-cognitive teaching strategies

Groups	N	Mean	SD
TA	140	16.82	2.885
SA	120	16.85	3.167
C0	100	16.22	2.095

Source	Type III Sum Of Squares	df	Mean square	F	Sig.	Partial Eta Squared
Pretest Score	1291.097	1	1291.097	307.983	.000	.464
Groups	958.070	2	479.035	114.271*	.000	.391
Error	1492.391	356	4.192			
Total	101542.000	360				
Corrected Total	2804.656	359				

a. R Square = .468 (Adjusted R Square = .463)

Table 3 shows the mean for thinking aloud is 16.82, self assessment 16.54 and conventional 16.22. This means that the mean different is statistically significant. This is because the F-value is 114.271 which is significant at 0.000 and also significant at 0.05 levels. The null hypothesis of no significant difference in performance of chemistry students among thinking aloud, self assessment and conventional groups is significant.Regression analysis shows that 46.3% contribution was skewed self assessment strategy.

IV. DISCUSSION

Hypothesis one is on the effect of thinking-aloud as a metacognitive teaching strategy. The result in testing this hypothesis indicated that students exposed to chemistry instruction using the thinking aloud strategy performed significantly better in the chemistry achievement test. This is because students have the opportunities to think aloud and report their thoughts, errors are corrected thereby leading to improved performance during the final assessment by their teacher. This is in agreement with what Lee and wha (1998) who found out that think-aloud method is a useful strategy for developing students' confidence in solving problems and provide a methodological approach for problem solving.

Jeon et al (2005) also observed that thinking aloud pair group performed better in problem solving compared to the control group and that thinking aloud strategy aid conceptual knowledge of chemistry. In another development Hafizah et al (2015) revealed that there was a significant improvement in student's problem solving behavior especially in understanding the problem.

Result in table 2 revealed that there is a significant difference between thinking – aloud and self assessment. Thinking-aloud and self assessment are metacognitive teaching strategy, however thinking-aloud strategy allows students to verbalize their thoughts thereby leading to high performance. This result is supported by Hafizah et al (2015) that found out that a significant improvement in students problem solving behavior especially in understanding the problem by applying the think-aloud strategy in mathematics lessons. This is in agreement with Pate (2009) who studied the effect of think aloud pair problem solving on secondary level students'

performance in technical education courses and found out that there was significant difference with students taught with think aloud strategies. However, Nbina and Viko (2010) observed that instruction in metacognitive self assessment strategy improves the student's chemistry achievement and self efficacy.

Data on table 3 shows that there is a significant difference among the metacognitive teaching strategies and the conventional strategy. This is because metacognitive teaching strategies are learner centered strategy which enables the learner to take charge of his or her own learning. This is supported by Cook et al (2013) who affirmed that teaching chemistry with metacognitive strategy will make students to learn better, retain and apply knowledge and also improve their performance This is also in agreement with Siburt et al (2011) that metacognitive teaching in chemistry will improve student attitude towards chemistry instruction and chemistry education. The study has bearing with Zhao et al (2013) that students taught metacognition in the classroom performed better on the last examination as opposed to students who were taught using traditional lecture method.

From the study metacognitive teaching strategies have significant effects on performance of students in chemistry. It is imperative that chemistry teachers should adopt these strategies to enhance performance in chemistry. Chemistry involves a lot of problem solving. These strategies will help students to possess the problem solving skills. Metacognitive strategies are learner centered teaching; it encourages collaborative learning which will help the students to think critically and constructively.

V. CONCLUSIONS

The study concludes that metacognitive teaching strategy such as thinking-aloud and self assessment if effectively utilized and applied by teachers in the cause of teaching science subject such as chemistry could significantly improve the performance of students.

It is therefore recommend that

1. Students should be taught using think-aloud metacognitive strategy as this has been found to improve their performance.
2. Thinking-aloud and self assessment metacognitive strategies should be used in teaching chemistry in secondary school rather than the conventional methods.
3. Metacognitive strategy should be adopted by teachers in teaching chemistry especially in this dispensation where the art of teaching is child centered.
4. In view of the importance of effectiveness of metacognitive teaching strategies, teachers should be trained to acquire the skills needed for use of the metacognitive strategies.

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