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Thinking aloud and self-assessment metacognitive strategies and chemistry students' achievement in organic compounds nomenclature

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Abstract
The study investigated the effect of thinking aloud and self-assessment metacognitive strategies and chemistry students' achievement in organic compounds nomenclature in Emohua Local Government Area of Rivers State, Nigeria. The study adopted the pretest post-test non-equivalent control group design. One hundred and twenty-five (67males and 58 females) senior secondary school (SSS 2) chemistry students were drawn from three secondary schools in Emohua local government area of Rivers State. Four research questions were answered while four hypotheses were tested at 0.05 level of significance. The instrument for data collection is a 50- item objective test on organic chemistry nomenclature achievement test (OCNAT). Mean, standard deviation and effect size were used to answer the research questions while t-test and ANCOVA were used to test the hypotheses. It was found that there is significant in the achievement of students when taught with thinking aloud and self-assessment strategies. Based on the findings, it was recommended among others that thinking aloud and self-assessment should be used to teach organic compounds nomenclature. The study concludes that thinking aloud and self-assessment is an effective tool in the delivery of organic chemistry concepts to the understanding of students.

Keywords: chemistry students, self-assessment, organic

Introduction
Chemistry is a branch of science which deals with the composition, properties and uses of matter. It probes into the Principle governing the changes which matter may undergo (Ababio, 2013) [1]. As a pure science subject, chemistry is seen as the central science because of its application in other aspects of pure sciences. Chemistry is the bedrock of technological advancement which has brought dramatic improvement in the standard of living of man. Chemistry helps to develop in the individual the skills of critical observation, experimentation, manipulation of variables, critical analysis as well as making deductions which are very important in the investigation of scientific processes (long - John & Pepple, 2010) [10].

Knowledge of chemistry through its contents and process has enabled us to produce good water for drinking, food, improved health care delivery through the production of drugs, materials for construction industries, roads and automobiles in our home (Nwokocha & Ahiakwo 2013) [16]. Chemistry knowledge is applied to solving problems relating to human interaction with environments like pollution, disease, epidemic, climate change and a host of others.

Despite the practical, scientific utilitarian and technological benefits of chemistry to nation building, its teaching and learning are characterized by a lot of challenges. These challenges are teacher factor, student interest, the lack of science resource among others has to lead to evident poor achievement in chemistry.

The poor performance in chemistry at secondary school level was attributed to shortage in science resources Obi and Idoha (2013) [17]. They asserted that for students to achieve better in chemistry, instructional materials should be used in teaching chemistry because chemistry requires real objects and activities/experiment that can convert topics that seem imaginary to concrete for students understanding.

Muhammad (2014) suggested that teachers are in a hurry and tend to rush through the scheme of work to enable them to cover the topic in the curriculum within the given period.

The West African Examination Council Chief Examiners report 2008-2014 indicated that candidates' poor performance in chemistry was due to the use of inappropriate and ineffective teaching methods by chemistry teachers. He went further to indicate that the poor performance in organic chemistry is the inability of candidates to draw the correct structure of organic compounds and naming them using the IUPAC nomenclature.

The dual problem of instructional strategy and students' ability can be solved through the use of an innovative and learner oriented strategy such as metacognitive strategy.

Metacognition refers to cognitive control and monitoring of all sorts of a cognitive process like perception, action, memory, reasoning or emoting (Wikipedia, 2015). Flavell referred to metacognition as one's knowledge concerning one's own cognitive processes and products or anything related to them. Tobias and Everson (2000) [24] defined metacognition as the ability to monitor, evaluate and make a plan.

Tobias and Everson organized metacognition in a hierarchical model which has knowledge monitor as a basis for activating other metacognition components. Tobia and Everson organised metacognition into a pyramid with knowledge monitoring at the base, followed by evaluating learning, select strategies and planning. Knowledge monitoring (KM) which is the ability to know what you know and knowing what you don't know is the prerequisite of the metacognitive process.

Learners who monitor their knowledge accurately evaluate their learning and select strategies which will empower them to plan and take charge of their cognitive process. Metacognitive strategies are strategies that are used by learners to manage and evaluate their learning activities (Fengua & Chen 2010) [4]. Metacognitive teaching strategies are used by the teacher to help learner plan, monitor and evaluate his or her cognitive activities.

Gamma 2004 [5], divided metacognitive strategies into seven, namely, reflective question and prompts, scaffolding, modelling, self-question, thinking aloud and self-explanations, self-assessment and graphic organizers.

Cook, Kennedy and McGuire (2013) say meta cognitive teaching strategies fall under constructive perspective teaching style which holds that students must be actively engaged in the learning process and that students should not be reduced to the terms of passive receivers of information. Rahman (2011) [21] assessed the impact of metacognitive awareness and performance of students and found out that students of highly metacognitive awareness have a higher mean score both the chemistry test and metacognitive inventory. Owo and Ikwut (2015) [19] affirms that metacognition and attitudes are good predicators of students' academic achievement as they correlate with chemistry achievement score and that metacognition is very critical in enhancing student's learning and academic achievement in chemistry. Similarly, Laureano, Espinosa and Avilla (2015) [9] asserted that self-regulation help students improve their academic performance and essentially become lifelong learners.

On the other hand, thinking aloud is a teaching technique developed by Whimby and Lochhead in 1989 to improve self-regulation during problem-solving. Lochhead (2000) [11] asserted that thinking aloud is a teaching technique used to force students to verbalize their thoughts and to gain more control over their thoughts. There are two types of thinking aloud, protocol and verbal analysis. Protocol analysis is used to measure problem-solving processes. While verbal analysis is used to measure knowledge and knowledge structuring.

Jeon, Huffman and Noh (2005) [8] investigated the effects of thinking aloud pair problem solving (TAPPS) approach on chemistry students' problem-solving performance and verbal interaction. The result revealed that thinking aloud group performed better than those in the other group in recalling related laws and mathematical execution and knowledge conception. Similarly, Hafitzah, Kani and Shadrill (2015) [6] found out that there is a significant improvement in students' problem-solving behaviour especially in the understanding of problems.

In another development Pate and Miller (2011) [20] studied the effect of thinking aloud pair problem solving on secondary-level students' performance in career and technical education courses and found out that students in TAPPS group were successful at the same task, however, there was no significant difference in completion time between treatment groups.

Self-assessment is simply judging the quality of one's work, it involves the process of assessing the quality of work done base on evidence and explicit criteria (Shunk, 1996). Metacognitive self-assessment is a metacognitive strategy where students observe and evaluate their performance. It involves the learner doing a personal assessment before the final assessment by the teacher. Self-assessment is an instructional strategy that leads to self-efficacy which is the confidence in one's ability to perform a specific task.

Mc Donald and Boud (2003) [12] revealed that 98% of students trained in self-assessment, felt it allowed them to improve their study habits, they knew how prepared they were for an assessment and had the opportunity to use the knowledge to improve their anticipated performance. In the same vein, Zimmerman and Kitsantas (2005) [26] assert that students who are highly regulated self-evaluate themselves in a more appropriate way and more frequently compared to those who are poorly regulated.

Nbina and Viko (2010) [14] investigated the effect of instruction in metacognitive self-assessment strategy on chemistry students self-efficacy and achievement and found out that it significantly improves chemistry achievement of students. The study also reveals that there is no significant difference in achievement between male and female students in chemistry.

Orimogunje (2014) [18] revealed that self-regulation learning strategies improve students' performance in chemistry. In the same development, Senol (2016) [22] revealed that students self-efficacy beliefs and metacognitive learning strategies were directly and positively correlated with their achievements. Alci (2015) [2] conducted a study on the influence of self-efficacy and motivational factors on academic performance in general chemistry course and found out that intrinsic motivation and self-efficacy are significant predicators of academic achievement in general chemistry. However, Feld Kamp (2013) [3] revealed that self-assessment slightly improves students' scores on summative assessment when comparing unit of similar perceived difficulties. Based on the importance of metacognitive strategies in teaching learning, this study is to find out the effect of thinking aloud and self-assessment teaching strategies on chemistry students' achievement in organic compounds nomenclature.

Aim and Objectives of the Study

The aim was to determine the effect of metacognitive teaching strategies such as thinking aloud and self-assessment and chemistry students' achievement in organic compounds nomenclature. Specifically, the study sought to:

1. Determine the effect of thinking aloud metacognitive teaching strategy on students' achievement in organic compounds nomenclature.
2. Examine the effect of self-assessment metacognitive teaching strategy on students' achievement in organic compounds nomenclature.
3. Ascertain whether the performance of students in thinking aloud metacognitive teaching strategy differs from those in the self-assessment metacognitive teaching strategy in organic compounds nomenclature.

Research Questions

Based on the stated objectives the following research questions guided the study.

1. What are the effect of thinking aloud and self-assessment metacognitive strategies on students' achievement in organic compounds nomenclature?
2. How does the performance of students in thinking aloud metacognitive teaching strategy differ from those in the self-assessment metacognitive teaching strategy in organic compounds nomenclature?

Hypotheses

The study the following hypotheses were formulated and tested at 0.05 level of significance.

1. There is no significant difference between pretest and post test scores of students taught organic compounds nomenclature with thinking aloud and self-assessment metacognitive strategies.
2. There is no significant difference in performance between the thinking-aloud and self-assessment group of students when taught organic compounds nomenclature

Methodology

The design of the study is a quasi-experimental design. Nwankwo (2016) [15] defines quasi-experimental design as partly true experimental design but it does not employ randomization procedure during assignment of subjects to groups. Specifically, this study adopted the pre-test post-test control group non-equivalent design. Symbolically the design is illustrated as follows:

E O1 X O2

……..

C O1 - O2

Where

E - Stands for experimental group
C - Control group
X - Treatment
O1 - pretest for experimental and control groups
O2 - post test for experimental and control groups.

The population of this study comprised 600 senior secondary two chemistry students in all public schools in Emohua Local Government Area, Rivers State**.** The sample size for the study was 125 senior secondary two (SS2) students selected via Simple random sampling technique.

Three instruments were developed for use in this study, Thinking-aloud instructional guide (TIG), Self-assessment instructional guide (SIG) and Organic Chemistry Nomenclature Achievement Test (OCNAT).TIG and SIG were used for intervention, while OCNAT was used for data collection. OCNAT is a 50- item test of multiple choices of an organic compound. OCNAT was validated and the reliability established as 0.95 via Kuder-k21 by using 50 students from Obio / Akpor Local Government that was not part of the main study as a measure of its internal consistency. A period of 3 weeks was used for the study. The research assistants were chemistry teachers of the sample school who were guided using the lesson package designed for the study. The pretest was administered to the students before the intervention, this was followed by an intensive period of instruction in organic compounds nomenclature two times per week for 3 weeks. The data collected for the study were analysed using mean, standard deviation and effect size to answer the research questions, while t-test and Analysis of covariance **(**ANCOVA) were used to test the formulated hypotheses.

Presentation of data

The results obtained are presented in tables.

Research Question 1: What are the effect of thinking aloud and self-assessment metacognitive strategies on students' achievement in organic compounds nomenclature?

Hypothesis 1: There is no significant difference between pretest and post test score of students taught organic compounds nomenclature with thinking aloud and self-assessment metacognitive strategies.

Table 1: t-test analysis of students mean pretest and post score on thinking aloud and self-Assessment metacognitive strategy

		Pretest		Posttest		MD	Df	t	Sig	Decision
Variables	N	$\bar{x}$	SD	$\bar{x}$	SD					
Thinking aloud	51	18.51	4.59	33.61	7.26	15.10	50	-12.62	.000	Sig
Self-assessment	74	23.57	9.65	35.73	12.07	12.16	73	-9.21	.000	Sig

The results in Table1 shows that the mean and standard deviation for thinking aloud metacognitive strategy pretest scores is 18.51 and 4.59 respectively while that of the post test scores is 33.61 and 7.26. This implies that the students post test scores in thinking aloud metacognitive teaching strategy is higher than their pretest scores with a mean difference of 15.10. Further statistical testing using dependent t-test the calculated t (50) = -12.62 P (0.000) <0.05, an indication that the calculated t is significant. The null hypothesis of no significant difference between pretest and post test scores of students taught organic nomenclature with thinking aloud metacognitive teaching strategy is rejected This implies that subjecting students to thinking aloud metacognitive teaching strategy enhances students' achievement in organic compounds nomenclature.

In the same vein, Table 1 shows that the mean and standard deviation for self-assessment metacognitive strategy pretest scores is 23.57 and 9.65 respectively while that of post test score is 35.73 and 12.07 and a mean difference of 12.61.The higher mean difference is an indication that self-assessment strategy improves students' achievement in organic compounds nomenclature. $t_{(73)}$ = -9.21 P (0.000)<0.05, is significant. The null hypothesis is rejected which implies a significant difference between pretest and post test scores of students taught organic compounds nomenclature with self-assessment metacognitive strategy.

Research Question 2

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

Hypothesis 2

There is no significant difference in performance between the thinking aloud and self-assessment group of students when taught organic compounds nomenclature.

Table 2: ANCOVA analysis of thinking aloud and self-assessment metacognitive strategies.

Source of variation	Sum of squares	df	Means squares	F	Sig.
Pretest scores	2063.571	1	2063.571	22.472	.000
Group(Main effect)	6.093	1	6.093	.066	.797
Error	11203.180	122	91.829		
Corrected Total	13402.688	124			

R square .164 (adjusted R squared = .150)

Table 3 shows that thinking aloud has a mean score of 33.61 and standard deviation of7.27 respectively while that of self-assessment mean is 35.73 and 12.07.The mean of self is slightly higher than thinking aloud, this implies that the performance of students taught with self-assessment metacognitive strategy is slightly better than those taught with thinking aloud metacognitive teaching strategy in organic compounds nomenclature. F (1,124), 0.066 P>0.05 is not significant, therefore the null hypothesis of no significant difference in performance between the thinking aloud and self-assessment group of students taught organic compounds nomenclature is accepted.

Discussion of Findings

The results in Table1 revealed that subjecting students to thinking aloud metacognitive strategy enhances understanding of organic compound nomenclature. This was due to the fact that students had the opportunity to think-aloud and report their thoughts, errors are corrected thereby leading to improved performance during the final assessment by their teacher. This result is in line with Lochhead (2000) [11] who asserted that thinking aloud is a technique used to force students to verbalize their thought to gain more control over their thought. It is also in agreement with Shahrikh, Morteza and Reza (2012) that when students think aloud they learn more and develop a reflective metacognitive independent learner, which is an invaluable step in helping them understand the learning requisite. The better performance of students in thinking-aloud is also attributed to the pairing of the students into groups. This agrees with Jeon, Huffman and Noh (2005) [8] that thinking-aloud pair group performed better in problem-solving. The result was also in line with what Olatoye, Aderogbe and Aanu (2011), that cooperative teaching enhances achievement of students in organic chemistry. The study slightly disagrees with Pate and Miller (2011) [20] who posited that only twenty-five percent in the TAPPS group was successful at the same tasks.

The study revealed that there is a significant difference in performance of students taught organic nomenclature using self-assessment metacognitive strategy as in Table 1. This is because self-assessment leads to self-directed learning in which the learner develop the skill of inquiring and judgment. This result is consistency with what Malemed (2015) asserted that self-assessment encourages learners to critically analyse their own assumption and this influence their learning. This is in agreement with what Nbina and Vikoo (2010) [14], Seol (2016) and Orimogunje (2014) [18] found out that instruction in metacognitive self-assessment strategy significantly improved chemistry achievement and self-efficacy in students.

Table 2 shows that there is no significant difference in the achievement of students when taught organic compounds nomenclature with thinking aloud and self-assessment metacognitive strategies. Thinking-aloud and self-assessment are metacognitive strategies which learners employ to performance task easier and better. That is the reason why Zhao, Wardeska, McGuire and Cook (2014) affirmed that metacognition help students to develop a plan for learning content, monitor their learning process through reflection and adjusting their plan accordingly in order to ensure deeper, more durable and more transferable learning. This result is in agreement with Ibe (2009) [7] and Rahman (2011) [21] who revealed that metacognitive strategies were effective in enhancing academic achievement in chemistry. The result is consistent with Cook, Kenndy and McGuire (2013) whose findings established a significant difference between students taught general chemistry with metacognitive strategies and those in the control group. The result further agrees with what Owo and Ikwut (2015) [19] with a similar finding that metacognition and attitudes are good predicators of students' academic achievement as they correlate with chemistry achievement score and that metacognition is very critical in enhancing student's learning and academic achievement in chemistry.

Conclusions

Organic compounds nomenclature is an integral part of the study of organic chemistry. Consequently, an effective teaching strategy for delivery to students understanding is imperative. Thus the outcome of this study bothered on teaching strategies of the thinking aloud and self-assessment as effective tools in the delivery of knowledge organic compounds nomenclature. Thinking-aloud and self-assessment metacognitive strategies are strongly advocated for the chemistry teachers to apply as far as the teaching of organic compounds nomenclature is a concern.

Recommendations

The study recommends that:

1. Students should be taught organic compounds nomenclature and another concept in organic chemistry using self-assessment metacognitive strategy found to enhance achievement of students.
2. Thinking aloud and self-assessment metacognitive strategy should be used to teach chemistry and other science subjects as it enables the learner to take charge of their learner.

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