Collection and analysis of students' metacognitive orientations for science learning: A survey of science classrooms in Delta State, Nigeria

O. Patrick Ajaja,
Delta State University, Abraka, Nigeria

Urhievwejire Ochuko Agboro-Eravwoke
University of Benin, Benin City, Nigeria

Abstract

The major purpose of this study was to explore the metacognitive orientations of science students at the secondary level of education. To achieve this, three research questions and hypotheses were raised, answered and tested at 0.05 level of significance. The design of the study was survey and samples consisted of 36 schools and 705 science students drawn from Delta state, Nigeria. The instrument used for data collection was Self-Efficacy and Metacognitive Learning Inventory Science (SEMLI-S). The major findings of the study indicated that: the metacognitive orientations scores of all the science students in all the groups and sub-scales of SEMLI-S fell within the rating of Half of the time used; all the science students were significantly varied in orientation in all the sub-scales of SEMLI-S; higher level students significantly outscored the lower level students on metacognitive orientations in all the sub-scales of the SEMLI-S; males significantly outscored the females on metacognitive orientations on Learning Risks Awareness and Control of Concentration. It was concluded that the knowledge of students' metacognitive orientations could help to improve classroom practices through the provision of clues on how students learn science and subsequent intervention of teachers when and where necessary.

Key words: control concentration, constructivist connectivity, self-efficacy, monitor, evaluation and planning, learning risks awareness.

Please address all correspondence to: O.P. Ajaja, Department of Science Education, Delta State University, Abraka, Nigeria, osawaruajaja@yahoo,com and O.U. Agboro-Eravwoke, Department of Curriculum and Instructional technology, University of Benin, Benin City, Nigeria, ejis4christ@yahoo.com

Introduction

Background of the study

To a great extent, most of today's classroom learning is focused on activities by which the learners acquire facts, rules and action sequences. The majority of lessons require outcomes only at the lower levels of cognition: knowledge, understanding and application leaving higher levels like: analysis, synthesis and evaluation. Spencer (1999) maintained that "emphasis has been on providing instruction rather that producing learning (p.568)", to the point where students can produce correct answers without true understanding of the concepts and implications (Sandi-Urena, 2008b). This may explain why some national studies of the state education in most countries (Ajaja, 2009, National Research Council, 1996) found many students unable to think independently of the teacher or go beyond the content in their texts and workbooks. Borich (2004) stated that:

> These reports suggests that the manner in which most schooling occurs may not be teaching students to become aware of their ownlearning, to think critically, and to derive their own patterns of thought and meaning from content presented (p.293).

This situation therefore calls for the use of an approach for both teaching and learning that actively engages students in the learning process to acquire higher order thinking outcomes.

One strategy for self-directed learning is metacognition. Borich (2004) defined metacognition as: "mental processes that assist learners to reflect on their thinking by internalizing, understanding, and recalling the content to be learned (p.297). Continuing, he stated that they include invisible thinking skills such as self -interrogation, self-checking, self-monitoring, and analyzing, as well as memory aids (called mnemonics) for classifying and recalling content. Research into metacognition has provided valuable insights for improving students learning but such activities have not been without their problems, many of which persist (Thomas, Anderson & Nashon, 2008). The major area of dispute is the conceptualization of the term "metacognition" and the activities associated with it. Wellman (1985) for example raised a concern that metacognition is a fuzzy concept that lacks coherence and that means many things to many people. Veenman, Hout-Wolters and Afflerbach (2006) while reacting to the concern raised by Wellman (1985) noted that although there is consistent acknowledgement of the importance of metacognition, inconsistency marks the conceptualization of the construct. Science education literature gave an array of different definitions of metacognition, examples are, knowledge, control and awareness of learning process (Baird, 1990; Thomas & Mc Robbie, 2004); ability to think about ones thinking (Gilbert, 2005); positing additionally that students' consideration of the status of their own science ideas (Blank, 2000); strategies and skills necessary to understand a task that is being performed (Saudi-Urena, 2008b); and metacognition occurs when individuals monitors and evaluate their own cognitive behaviours in a learning environment (Ayersman,1995). Veenman et al (2006) also noted that terms such as self-regulation, metacognitive awareness and learning strategies are commonly associated with metacognition. To put the issues straight and make the concept clearer and understandable, Schraw, Cripper and Hartley (2006) contended that metacognition are the strategies and processes that students employ as subsets of self-regulation and that other elements of self-regulation such as self-efficacy, the extent to which individuals are confident in relation to performance of tasks or goal attainment are also influential in determining learning out comes.

The assessment of metacognition is intrinsically difficult because it is not an overt behaviour. It is not only an array of inner processes but rather often individuals are not fully aware of them. The vast majority of the studies carried out on the measurement of metacognition of science students which have relied on procedures like systematic observation, questionnaire (self-reporting) and think aloud protocols have not been able to popularise its use in science teaching and learning. This is because of lack of clear understandings of the components by both teachers and students. Consequently, a current need for the identification and measurement of the metacognitive levels of science can be inferred. This indeed is the rationale for the study.

Research on metacognition has its root from the work of Flavell (Georghiades, 2004; Hartman, 1998;Wolter, 1987). Since Flavell's seminal work on metacognition (Flavell 1976, 1979), there has been continual interest in research into how to develop, enhance and measure metacognition (Thomas et al, 2008). Veeman, et al (2006) highlighted other terms associated with metacognition: metacognitive beliefs, metacognitive awareness, metacognitive experiences, metacognitive knowledge, feeling of knowing (FOK), judgement of learning (JOL), metacomponents, comprehension monitoring, theory of mind, metamemory, metacognitive skills, executive skills, high-order skills, learning strategies, heuristic strategies and self regulation. Metacognition as a construct is often considered to confer attention on the improvement of students' learning processes and consequently their learning out comes (Thomas et al, 2008). This observation has helped to focus more research in this field, since metacognition is believed to have the potential that students learning processes can be developed and improved. White, (1988), Thomas and Mc Robbie (2001) while discussing the importance of metacognition noted that the role of metacognition lies in its potential to explore, explain and ultimately to improve students' thinking and learning processes. In the words of Thomas et al (2008) "such a possibility promotes optimism in education circles and provides an alternative to deficit models of cognition that so often view students' learning potentials as fixed, pre-determined, and beyond the salvation of any form of intervention (p.1702).

Still on the importance of metacognition, it is thought of as the strategies and skills necessary to understand a task that is being performed (Saudi-Urena, 2008). This by implication means the ability to use task or goals appropriately and discuss its use. Swanson (1990) in his contribution noted that the influence and relevance of metacognition in learning and problem-solving has been substantially demonstrated, and in fact it has been shown to compensate for lower cognitive abilities. This is a quality highly sort for in instructional strategies by science education researchers for effective learning by all science students' irrespective of their abilities and sex. This is essentially the desire, hope and focus of science education research in the 21st country. Based on these findings from literature on the importance of metacognition in learning , it is not surprising then that over the last three decades, a great deal of interest in instructional enhancement of metacognition use has surged (Blank & Hewson, 2000; Davidowitz & Rollnick, 2003; Georghiades, 2004).

This study specifically addresses two main questions in the field of metacognition research: the assessment of metacognitive orientations of science students at the senior secondary level of education and comparison of metacognitive orientations of science students at different levels and between sexes.

Statement of the Problem

This study grew from the still existing confusion about the conception of metacognition, its attributes and limits. This position is anchored on the comment made by Wellman (1985) that metacognition is a "Fuzzy" concept that lack coherence and means many things to many people. This development therefore calls for more research that will make the meaning clearer, define its limits and popularise its use in the teaching and learning of science. Specifically, the statement of the problem is, will the assessment of science students metacognitive orientations provide clues on its conception by students, extent of its use in science learning and possible integration into models of science teaching?

Research Questions

The following research questions were asked to guide the study.

1. What are the metacognitive orientations of science students at the senior secondary level of education?
2. Is there any difference in metacognitive orientation scores among science students in different levels?
3. Is there any difference in metacognitive orientation scores between male and female science students?

Research Hypotheses

The following hypotheses are tested at 0.05 level of significance.

H_{01}: There is no significant difference in metacognitive orientations of science students among the subscales of SEMLI-S (CC, MEP, SE, AW & CO).

H_{02}: There is no significant difference in metacognitive orientation scores among science students in different levels (SS I, II, & III).

H_{03}: There is no significant difference in metacognitive orientation scores between male and female science students.

Materials and Methods

Design of the study

The design employed for the study of metacognitive orientations of science students in Delta State, Nigeria, was survey. The study specifically collected the metacognitive orientations of science students (Biology, Chemistry and Physics) in senior secondary school classes [SS1,11 & 111] in Delta State, using a (self reporting protocol) questionnaire. Johnson and Christensen (2000), Thorndike and Hagen (1997) and Wiseman,(1999) stated that any study where the instrument used for data collection is a questionnaire; the appropriate design for such a study is survey. This specified condition thus justifies the choice of survey designs since questionnaire was the main instruction used for data collection.

Population and sample of the study

The population of study consisted of all the science students at the senior secondary level of education (SS1, 11 & 111) in Delta state. There are four hundred and fifty five (455) secondary schools distributed among the three senatorial districts in Delta State. The senatorial districts include Delta North, Delta South and Delta Central. The senatorial districts are further divided into local government areas for easy administration. In all there are twenty five local government areas in Delta State.

The sample consisted of seven hundred and five (705) science students drawn from thirty six (36) public schools in the state. From each senatorial district, only twelve mixed schools were selected. The selected schools in each senatorial district reflected six urban and six rural schools.

The first step in the selection of the sample involved the deliberate elimination of the single sex and private schools from the population from where the sample was drawn. The decision to do this was to reduce the cost of movement during data collection and still maintaining a fair representation of all sexes in the sample. Simple random sampling approach using balloting was adopted in the selection of the schools. The students sampled were not selected in each of the school since all science students in the selected schools were used as participants. The decision to use all the science students in all the sampled schools was to reduce the effects of other intervening variables peculiar to different schools from affecting the result significantly. The result obtained from this structure will be more stable and reliable than if samples of students from more schools were selected and used. This however, calls for a replication of the study using the entire country were more schools and students will be used as participants.

Instrument

The instrument used for the study was a self report measure (questionnaire) which probes students metacognitive knowledge and their perceived use of metacognitive strategies that ask students to consider the nature and extent of their cognition and metacognition and rate their use of cognitive and metacognitive processes. The instrument is called Self-Efficacy and Metacognition Learning Inventory Sciences (SEMI-S) developed by Thomas, Anderson and Nashon (2008). The instrument shown in appendix 1 is framed on a five point Likert scale of; 1 = never or only rarely, 2= sometimes, 3= half of the time, 4= frequently, 5=always or almost always. The instrument is a thirty item (30) scale developed under five (5) subscales; Constructivist-Connectivity; Monitoring, Evaluations and Planning; Self-Efficacy, Learning Risks Awareness, and Control of Concentration.

This instrument (SEMLI-S) was adopted for this study because of the limitation associated with most existing empirical self-report instruments that explore students learning and metacognition (Thomas et al, 2008) which do not account for the classroom context or help students locate their self report in relation to the learning of specific subjects such as sciences. Since this study assessed the metacognitive orientations of science students at the secondary level of education, this choice of instrument was most appropriate. To drive this point home, Gunstone (1994) and Thomas and Mc Robbie (2001) made a strong case for the need to acknowledge the importance of nature of sciences content and process when investigating metacognition in sciences and learning process. This quality is properly shown in the subscales of the instrument (SEMLI-S) as described below in appendix 1.

The instrument has initially been validated by Thomas et al (2008) but for the fact that the instrument was adapted to a new environment far away from the environment were it was developed, the instrument was revalidated to confirm its internal consistency. The instrument was developed by Thomas et al (2008) using Hong Kong environment. The culture and school system of Hong Kong may not be similar to what operates in Nigeria since the need for revalidation.

Content Validity

The validity of SEMLI-S was first determined by a panel of five judges: three specialists in sciences education (Biology, Chemistry& Physics) one expert in Measurement and Evaluation, and one secondary school science teacher. They mainly examined the contents of the SEMLI-S, the research questions and hypotheses to determine if the instrument will be able to generate the appropriate data to answer the research questions and test the stated hypothesis. To facilitate the job of the judges, the SEMLI-S, research questions and hypotheses were made available to them. The three documents assisted the judges in reaching fair decisions. The members of the panel who worked independently forwarded their observations to the researchers. All the members of the panel confirmed and approved the appropriateness of the items in the SEMLI-S for the study and since no corrections were recommended; all the items in the instrument were retained.

Construct Validity

To determine the construct validity, quality of individual questions and estimate of reliability of SEMLI-S, a pilot test was conducted. This involved the administrations of SEMLI-S to 60 science students (20 each from SS1,11 &111 respectively) in Ime-obi secondary school, Agbor that agreed to participate in the pilot study. The characteristics of the pilot school was similar to the characteristics of the sampled schools science students but were not part of the sample selected for the study. The findings of interest determined with the pilot study are;

Factor Analysis The determination of construct validity of SEMLI-S involved a series of factor analysis being carried out. This involved the extractions method known as Principal Component Analysis and Rotation Method known as Quartrimax with Kaiser Normalisation. Our standard was retaining only items with Eigen values of at least 1. On analysis of the responses of the 60 sciences students (respondents) all the items in the SEMLI-S were retained because all had the Eigen values of at least 1 as recommended.

Item Difficulty The difficulty of each item was determined with Kuder Richardson 20 procedure for estimating internal consistency of a test. This was accomplished by dividing the number of subjects who chose option that agreed with a students' right metacognitive orientation by the number of subjects who made attempt by choosing other options. The range of possibilities in item difficulty is between 0.00 and 1.00 (Wiseman 1999). The higher the difficulty index, the easier the question. Wiseman (1999) specifically stated that items with difficulty indices of 0.00 - 0.2 are too difficult while those with 0.8 -1.0 are too easy. In line with these specifications only item with difficulty indices of 0.3 - 0.7 were recommended for selection into the instrument. All the items in the SEMLI-S were retained since their difficulty indices fell within the recommended range of 0.3 – 0.7.

Estimate of Reliability

The reliability of SEMLI-S was determined using the Cronbach's alpha approach. It is also referred to as coefficient alpha and Cronbach's coefficient alpha (Cronbach, 1951), enables one to estimate internal consistency when the scoring of items on a test is not limited to 1 point (for correct) or 0 points (for incorrect response). The SEMLI-S framed on a 5 point likert scale, thus points that the cronbach alpha procedure is the appropriate measure for determining its reliability. This involved the administration of the SEMLI-S to 60 sciences students who were not part of the study, their scored responses were substituted in the cronbach alpha formula to determine the internal consistency of the instrument. The Cronbach alpha value obtained was 0.78. This agreed with the reliability standard already established (Thorndike & Hagen, 1997; Wiseman, 1999; Johnson & Christensen, 2000; Borich, 2004) that any instrument with a reliability index of 0.7 and above is adjudged as being reliable.. On the bases of this, the instrument was used for the data collection as a reliable instrument.

Data Collection Procedure

The metacognitive orientations of 705 sciences students were collected personally by the researchers for three weeks using the SEMLI-S instrument. One week each was spent in the collection of data from each senatorial district. In each senatorial district, only twelve of the randomly selected schools were visited. Specifically in each of the selected schools visited, the researchers after obtaining expressed permission from the school head (Principal) form teachers and sciences teachers (Biology, Chemistry Physics) administered the instrument (SEMLI-S) to the sciences students in all levels (SS1, 11, & 111). Before they were allowed to respond to the questions in the SEMLI-S, the rules guiding their participation were read to them. They were told that the questionnaire will be collected from them after one hour and advised not to share ideas with their mates as that will constitute an offence punishable by expulsion from class. To get them serious with the exercise, the researchers appealed to the sciences teachers to assist in the conduct of the exercise and promised the students, that the best student will get a scholarship award at the end of the study. This strategy made the classroom atmosphere very calm.

At the expiration of one hour, the SEMLI-S instrument (self -reporting questionnaire) were collected from the students. The responses of the respondents (science students) were scored by the researchers at later dates (at the end of data collection). The responses of the students and the analysis of the data generated were summarised in tables discussed under results.

Two major statistics were used in the analysis of data collected. Students t- test was used to test for significant difference in metacognitive orientation between the male and female sciences students and one sample t-test (a kind of t-test) was used to test if there was significant difference among the science students on all the sub-scales. Analysis of Variance (ANOVA) was used to determine significant difference exist in metacognitive orientations among the class levels (SS1, 11 &111). The significant level for all the statistics was 0.05.

The suitability of the statistics for the analysis of the collected data was achieved by subjecting the collected data to a series of the tests. For the t test, two tests, of normality (Kolmogorov- $Smimov_a$ and Shapiro- Wilk tests) were carried out. The statistics correlation values obtained (Kolmogorov- $Smimov_a$ =0.208, sig. at 0.002, and Shapiro - Wilk= .966, sig at 0.004) indicated significant correlation

The appropriateness of the use of Analysis of Variance (ANOVA) was determined by carrying out a test of Equality of Error Variance with Levenes's test. A reference to the design which showed the independent and dependent variables, identified five groups (2 groups on sex and 3 groups on class level). Levene's test of the Equality of Variances which is a homogeneity test on the five groups of data showed an F-value of 0.097, sig at 0.986. What guides decision here is the "significance" value. As shown F-value of 0.097 is not significant and therefore there is no reason to doubt the assumption of the homogeneity of variance across the groups. This indeed confirmed the appropriateness of the statistic (ANOVA) used for analysis.

Result and Discussion

Results

Table 1: Differences in students' response across class levels and sex in SEMLI-S sub - Scales

Sample	CC	MEP	SE	AW	CO
Overall (n=705)	3.22	3.45	3.62	3.52	3.56
SSI (n=270)	3.05	3.36	3.53	3.20	3.30
SSII (n=215)	3.15	3.58	3.79	3.66	3.75
SSIII (n=220)	3.49	3.42	3.59	3.78	3.71
Male (n=325)	3.22	3.44	3.70	3.73	3.62
Female (n=380)	3.21	3.46	3.56	3.34	3.51

Shown in table 1, there is no clearly defined pattern of metacognitive orientations among the groups . The range of metacognitive orientation scores was 3.05 - 3.79 among all the groups. However, SS11 and SS111 students scored higher on metacognitive orientations than the SS1 students across all the sub-scales of the SEMLI-S. Also shown in the table, except for MEP sub-scale, the male students scored higher on metacognitive orientations than the female students. To determine if the differences found among the individuals and groups are significant, the data collected were subjected to other statistical tests, the results of which are shown in tables below.

Table 2 One sample t-test comparison of metacognitive orientation scores of all science students in the sub-scales.

Sub-scales	t	df	Mean difference	sig
CC	123.897	704	3.222	0.000
MEP	146.194	704	3.447	0.000
SE	129.920	704	3.624	0.000
AW	114.252	704	3.520	0.000
CO	105.275	704	3.653	0.000

The table indicated significant differences on metacognitive orientation scores among the science students in all the sub-scales. This was based on the fact that the calculated t-values for all the sub-scales were greater than the critical t-value of 1.960. With this result, HO_1 was rejected because the differences were found to be significant.

Table 3 ANOVA analysis comparing SS1, S11, and SS111 science students on metacognitive orientations in SEMLI-S sub-scales

SEMLI-S	SS1	SSII	SSIII

Sub-scales	**Mean**	**Mean**	**Mean**	**F**	**P**
CC	3.05	3.15	3.49	28.520	0.000
MEP	3.36	3.58	3.42	7.254	0.001
SE	3.53	3.79	3.59	7.891	0.000
AW	3.20	3.66	3.78	37.638	0.000
CO	3.30	3.75	3.71	20.598	0.000

Table 3 showed significant difference on metacognitive orientation scores in CC, MEP, SE, AW and CO among SS 1, 11 and 111 students. This was based on the fact that the calculated F-values for the various SUB-SCALES were greater than the critical F-value of 2.014. CC F= 28.520; P<0.05; MEP F=7.254, P<0.05;SE F= 20.598,P<0.05; SE F=7.891,P<0.05,AW F=37.638,P<0.05; and CO F= 20.598, P< 0.05. With this result, $H0_2$ was rejected, because the SS 1, SS11 and SS111 were significantly different on all the sub-scales of SEMLI-S. To determine the direction of significance, Scheffe's Multiple Comparison test was employed. The results of Scheffe's test are summarised in tables below.

Table 4: Scheffe post-hoc test comparing SSI, II and III on (CC) constructivist connectivity

Level (I)	**Level (J)**	**Mean Difference (I-J)**	**Std.Error**	**Sig**
SSI	SSII	-0.107	0.601	0.205
	SSIII	-0.440 *	0.060	0.000
SSII	SSI	0.107	0.601	0.205
	SSIII	-0.332 *	0.063	0.000
SSIII	SSI	0.440 *	0.598	0.000
	SSII	0.332 *	0.063	0.000

Table 4 indicated the following: (i) SS111 students significantly scored higher metacognitive orientation scores on CC than SSI and SSII students. (ii) There was no significant difference in metacognitive orientation scores on CC between SSI and SSII students.

Table 5: Scheffe post-hoc test comparing SS1, SS11 and 111 on (MEP) monitor, evaluation and planning

Level (I)	Level (J)	Mean Difference (I-J)	Std. Error	Sig
SSI	SSII	-0.211 *	0.057	0.001
	SSIII	-0.056	0.056	0.608
SSII	SSI	0.211 *	0.057	0.001
	SSIII	0.156 *	0.056	0.033
SSIII	SSI	0.056	0.056	0.608
	SSII	-0.156 *	-0.060	0.030

Table 5 shows that on MEP, SS11 students significantly had higher metacognitive orientation scores than SS1 and SS111 students. There was no significant difference in metacognitive orientation scores between SS1 and SS111 students on MEP.

Table 6: Scheffe post-hoc test comparing SSI, II and III on (SE) self-efficacy

Level (I)	Level (J)	Mean Difference (I-J)	Std.Error	Sig
SS1	SSII	0.259 *	0.067	0.001
	SSIII	0.059	0.667	0.679
SSII	SSI	0.259 *	0.067	0.001
	SSIII	0.200 *	0.070	0.018
SSIII	SSI	0.059	0.666	0.679
	SSII	-0.200 *	0.070	0.180

Table 6 indicated that on SE, SS11 students significantly scored higher orientation scores than SS1 and SS111 students. There was no significant higher metacognitive orientation scores between SS1 and SSII students.

Table 7: Scheffe Post-hoc test comparing SSI, II and III on (AW) learning risks awareness

Level (I)	Level (J)	Mean Difference (I-J)	Std.Error	Sig
SS1	SSII	-0.452 *	0.0712	0.000
	SSIII	-0.574 *	0.071	0.000
SSII	SSI	0.453 *	0.072	0.000
	SSIII	-0.121	0.075	0.267
SSIII	SSI	0.574 *	0.071	0.000
	SSII	0.121	0.075	0.267

Shown in table 7 and on AW, SS111 and SS11students significantly out scored SS1 students on the metacognitive orientation. No significant difference on metacognitive orientation scores was found between SS11 and SS111 students.

Table 8: Scheffe Post-hoc test comparing SSI, II and III on (CO) control concentration

Level (I)	**Level (J)**	**Mean Difference (I-J)**	**Std.Error**	**Sig**
SSI	SSII	-0.455 *	0.099	0.000
	SSIII	-0.412 *	0.074	0.000
SSII	SSI	0.455 *	0.079	0.000
	SSIII	0.042	0.084	0.878
SSIII	SSI	0.412 *	0.079	0.000
	SSII	-0.042	0.084	0.878

Table 8 indicated that on CO, SS11 and SS111 students significantly out scored SS1 students on metacognitive orientation. There was no significant difference between SS11 and SS111 students on metacognitive scores.

Table 9: t-test analysis comparing male and female science students on metacognitive orientations in SEMLIS-S sub-scales

Sub-scales CC	**Sex**	**N**	**Mean**	**SD**	**df**	**t-cal**	**Table-t**	**P.**
	Male	325	3.22	-0.73568	703	0.257	1.960	0.05
	Female	380	3.21	0.63580				
MEP	Male	325	3.44	0.60875	703	0.403	1.960	0.05
	Female	380	3.46	0.64100				
SE	Male	325	3.70	0.63019	703	2.524	1.960	0.05
	Female	380	3.56	0.81889				
AW	Male	325	3.74	0.83042	703	6.599	1.960	0.05
	Female	380	3.34	0.76240				
CO	Male	325	3.63	0.85468	703	1.689	1.960	0.05
	Female	380	3.51	0.93269				

Table 9 shows that there is no significant difference between male and female science students on metacognitive orientation scores in sub-scales CC, MEP and CO. This was based on the fact the calculated t-values in these sub-scales were less than the critical t value of 1.960, t= 0.257,0.403 and 1.689, P>0.05. With this result $H0_3$ was retained for sub-scales, CC, MEP and CO because the males and females are not significantly different.
However, for sub-scales SE and AW, the table indicated significant differences since the calculated t-values were greater than the critical t-values. For this reason $H0_3$ was rejected for sub-scales SE and AW. The males significantly outscored the females in the two sub-scales.

Discussion

Ajaja (2013) noted that the major focus of research in science education is to isolate the appropriate methods and strategies which can guarantee effective teaching and cause effective learning by students. Research on metacognition had its origin in the 1970 work of Flavell (1976 and 1979). This work focused on children knowledge and control of their memory processes. Within a decade of Flavell and Brown's work, hundreds of studies had accumulated showing that metacognitive knowledge and control were associated with more successful cognitive performance (Baker, 2009). Baker (2009) stated that when students have knowledge and control of their own cognitive processes, learning is enhanced; this assertion holds regardless of the domain of learning, whether reading, writing , science , mathematics, or any other activities that involves thinking.

Literature on metacognition further indicated that instructional approaches that foster metacognition can enhance not only students learning but also students' responsibility for learning. The National Research council committee in the later 1980's led by John Bransford, Ann Brown, and Rodney Cocking (Baker, 2009), concluded that metacognition is a key factor in learning that should be deliberately cultivated. They emphasized that metacognition fosters and promotes transfer of learning.

However, inspite of these lofty qualities ascribed to metacognition, there do not seem to be enough inclusion of metacognitive activities in science teaching and learning. The non-inclusion of metacognitive activities in science teaching and learning may be the reason for the dispute in the conceptualization of the term "metacognition" and the activities associated with it. This study therefore, is timely and significant since the major rationale for the study was to popularise the need for inclusion of metacognitive activities in science teaching and learning. This may have been achieved in this study through clarification of the concept by showing clear and specific examples of its components to show limits, and demonstrating the procedure for determining metacognitive orientations of science students in the classroom.

The most noticeable finding of this study is the short range in metacognitive orientation scores of 3.05-3.79 across all the groups. The range values suggest that all the science students studied agreed that they only spend half of the time on metacognitive activities during learning. This indeed, may have accounted for their poor performances in sciences over the years. The significant differences on metacognitive orientation scores of all science students in the sub-scales and class level in all the sub-scales were expected. The higher metacognitive orientation scores of students in SS11 and SS111 over those in SS1 in all sub-scales are noteworthy. The ANOVA analysis showed that class level could be used to predict metacognitive orientations of science students.

However, while the significant influences of class level and sex on science students metacognitive orientation is applauded, several specific observations were made about the findings in relation to the sub-scales. First, the analysis indicated significant differences on metacognitive orientation scores among all the science students in all the sub-scales. This variation among the science students may be explained with the strict selection policy in promoting science students from junior secondary to senior secondary in Nigeria. Only students who scored very high marks in Integrated Science and Mathematics in Junior Secondary School Certificate Examination are admitted to senior secondary one (SS1) to study science. This finding is consistent with the finding of Thomas et al (2008). They noted in the study they carried out in Hong Kong that students are selectively screened for further science schooling by highly competitive examinations at form three and form five and resulted in the students highly varied. Another possible reason for variability among the science students on metacognitive orientation is age difference. Some studies confirmed this. Bransford, Brown and Cocking (2000) noted that metacognition develops gradually. Baker (2009) found that metacognitive growth is gradual throughout childhood, adolescence, and even into adulthood. Baker (2009) further stressed that ability -related differences, in knowledge about cognition like developmental differences, have been documented in countless studies, across age groups ranging from early childhood through later adulthood.

Secondly, the analysis shows that SS1,11 and 111 students are significantly different on metacognitive orientation scores in all the sub-scales (CC,MEP,SE,AW&CO). The post -hoc test on CC indicated that SS111 outscored the SS11 and SS1 students. The Post-hoc test on MEP showed that SS11 students scored higher metacognitive orientation scores than SS111 and SS1 students. Also the post hoc test on SE indicated that SS11 students significantly scored higher metacognitive orientation scores than SS1 and SS111 students. Again Post hoc test on AW indicated that SS111 and S11 students significantly outscored SS1 students on metacognitive orientation. The post hoc test on CO indicated that SS11 and SS111 students significantly outscored SS1 students on metacognitive orientation. These findings indicated a particular trend, that the higher levels (SS11&111) significantly scored higher on the metacognitive orientation in all the sub-scales (CC, MEP, SE, AW & CO). These findings are consistent with the findings of Thomas et al (2008) on CC, MEP and AW sub-scales. They postulated that it might be expected that science students at more advanced levels of schooling would report higher levels of CC, MEP, and AW as these might be expected to be characteristics of successful learners of science and therefore higher science achievers. The lack of statistically significant higher scores for the SE among SS111 students may be explained with the suggestions of Thomas et al (2008) that the students do not feel any more confident about their self-efficacy as they pass through school despite their success. This suggestion could be buttressed with the stand of Perkins (1992) that the development was due to lack of a meta-curriculum in schools. The lack of statistically significant difference for CO sub-scale between SS11 and SS111 students indicates the concentration of the students remain stable. This again agreed with the finding of Thomas et al (2008) that for CO, students' attention to concentration remains reasonably stable overtime. The stability in concentration of SS11 and SS111 students as found in this study may be explained with the fact that students at this level are already well experienced and understand why they are in school.

Thirdly, the analysis showed that no statistically significant differences were found between males and female students on the sub-scales CC, MEP and CO. This implied that male and female students' application of constructivist ideas (CC) and monitoring, evaluation and planning (MEP) in their learning activities falls within a close range which are not statistically significant different. This may not be unconnected with the non-injection of metacognitive activities into instruction by teachers. The male and female students' knowledge of metacognitive skills may be about the same thing and are not applied regularly in their learning. The male and female students' control of concentration (CO) was not significantly different. This may be explained with the fact that all of the students came from the same background and thus had similar orientation about schooling and learning. The statistically significant higher metacognitive scores of males over females in SE and AW may be explained with the change of role theory. The theory notes that as the males mature and are about to graduate from high school to the tertiary institution, they attempt to become more serious with their studies to acquire all the skills necessary to become the head of a family. This behavioural adjustment may have influenced their having more confidence in themselves and critically examining the risks they take. For the females in the same class level; they become more conscious about themselves and dispose themselves in a way to attract males for possible marriage (Ajaja, 2012). The females at this level show less confidence in themselves and are less willing to question the academic risks they take.

Conclusion

The study which explored the science students metacognitive orientations, gave an insight into science students self-perceptions of their metacognition, self-efficacy and science learning processes. The findings of this study can provide feedbacks for science students in relation to their development of metacognitive knowledge and for teachers on the needs to include metacognitive interventions in instructions. Baker (2009) specifically stressed that teacher- led interventions using metacognitively oriented reading instruction have resulted in gains in students' metacognition as well as comprehension.

For proper classroom practices, measuring students' metacognitive ability can help teachers find out how well students learn science and identify specific areas that need support among the students to improve their abilities. The role metacognitive intervention plays in instruction has been found to be so strong in teaching-learning process that disciplinary organisations and national panels recommended that metacognition be included in teacher preparation and in classroom curricula (Baker, 2009).

References

Ajaja O.P. (2009). Evaluation of science teaching in secondary schools in delta state 2- Teaching of the sciences. *International journal of educational sciences*, 1 (2),119-129.

Ajaja O.P. (2012). Unequal achievement of science undergraduates: Does sex influence the differences. *Us-China Education Review B*, 2(6), 578-594

Ayersman, D.J (1995). Effects of knowledge representation format and hypermedia instruction on metacognitive accuracy. *Computers in Human Behavior*, 11 (3–4) , 533–555

Baird, J.R. (1990). Metacognition, purposeful enquiry and conceptual change. In E. Hegarty-Hazel (Ed), *The student laboratory and the science curriculum* (183-200).London: Rutledge.

Baker, L. (2009). Historical roots of inquiry in metacognition Retrieved from http://www.education.com on 25th November, 2013

Blank, L.M. (2000). A metacognitive learning cycle: A better Warranty for student understanding? *Science Education*, 84(4),486-506.

Borich, G.D. (2004). *Effective teaching methods, fifth edition*. New Jersey: Merrill, Prentice Hall

Bransford,J.D; Brown, A.L. & Cocking, R.R (2000). *How people learn: Brain, mind, experience, and School*. Washington,D.C.: National Academy Press

Cronbach, L.J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika*,16,297-334.

Davidowitz, B., & Rollnick, M. (2003). Enabling metacognition in the Laboratory: A case study of four second year university chemistry students. *Research in Science Education*, 33, 43-69

Flavell, J.H. (1979). Metacognition and cognitive monitoring: A new area of cognitive-development inquiry. *American Psychologist*,34,906-911.

Flavell, J.H.(1976). Metacognitive aspects of problem solving. In L.B. Resnick (Ed). *The nature of intelligence*, (231-235). Hillsdale,NJ:Erlbaum.

Geoghiades, P. (2004). From the general to situated: Three decades of metacognition. *The international Journal of Science Education* ,26 (3), 365-383

Gilbert, J.K (2005). Visualization: A metacognitive skills in science and science education. In J.K. Gilbert (Ed), *Visualization in Science Education* (9-27), Dordrecht, The Netherlands, Springer.

Gunstone, R.F.(1994). The importance of specific science content in the enhancement of metacognition. In P.J. Fensham, R.F.Gunstone, & R.T. White (Eds), *The content of science*. London: Falmer

Hartman, H.J. (1998). Metacognition in the teaching and learning: An introduction. *Instructional Science,* 26(1-2), 1-3

Johnson, B. & Christensen, L. (2000). *Educational research*. Boston: Allyn and Bacon.

National Research Council (1996). National science education standards 1995. Washington, D,C: National Academy Press

Perkins, D,N, (1992). *Smart schools*: *From training memories to educating minds.* New York: The Free Press.

Sandi-Urena, S. (2008a), Design and validation of a multi-method assessment of metacognition and study of the effectiveness of metacognitive interventions. Unpublished Ph.D Thesis of Clemson University

Sandi-Urena, S. (2008b), Reliable multi-method assessment of metacognitive use in chemistry problem solving. *Chemistry Education Research and Practice ,*9, 18-24

Schraw, G., Crippen, K.J, & Hartley, K.D (2006). Promoting self-regulation in science education: Metacognition as part of a broader perspective on learning. *Research in Science Education*, 36 (1-2),111-139

Spencer, J., (1999). New directions in teaching chemistry: A philosophical and pedagogical basis. *Journal of Chemical Education*, 76(4), 566-569

Swanson, H.L. (1990). Influence of metacognitive knowledge and aptitude on problem solving. *Journal of Educational Psychology*, 82, 306–314

Thomas, G., Anderson, D & Nashon, S. (2008). Development of an instrument designed to investigate elements of science students ' metacognition, self-efficacy and learning processes: The SEMLI-S. *International Journal of Science Education,* 30(13), 1701-1724.

Thomas, G.P., & Mc Robbie, C.J. (2009). Using metaphor for learning to improve students' metacognition in the chemistry classroom. *Journal of Research in Science Teaching,* 38(2), 222-259

Thorndike, R.L & Hagen, E.P.(1997). *Measurement and evaluation.* New York: John Wiley and sons

Veenman, M.V., Hout-Wolters, B.H.A.M, & Afflerbach,P. (2006). Metacognition and learning: Conceptual and methodological consideration. *Metacognition and Learning*,1,3-14

Wellman, H. (1985). The origin of metacognition. In G. Thomas, D. Anderson, & S. Nashon, article " Development of an instrument designed to investigate elements of science students ' metacognition, self-efficacy and learning processes: The SEMLI-S. *International Journal of Science Education,* 30(13), 1701-1724

White, R.T. (1988). Metacognition. In J.P Keeves (Ed), *Educational Research, methodology, and measurement.* (70-75). Sydney: Pergamon Press.

Wiseman, D.C (1999). *Research strategies for education*. New York: Wadsworth publishing.

Wolters, M.A. (1987). Schooling and the development of metacognition. In proceedings of the second International Seminar: Misconceptions and Educational Strategies in Science and Mathematics, July 26-29, 1987 Cornell university, Ithaca, NY, USA.

Appendix I Self-Efficacy Metacognition Learning Inventory-Science (SEMLI-S)
Appendix. Final version of the SEMLI-S

DIRECTIONS

1. **Purpose of the Questionnaire**

 <u>This questionnaire asks you to describe HOW OFTEN you do each of the following practices when science.</u> There are no right or wrong answers. This is not a test and your answers will not affect your assessment. **<u>Your opinion is what is wanted.</u>** Your answers will enable us to improve future science classes.

2. **How to Answer each Question**
 On the next few pages you will find 30 sentences. For each sentence, circle <u>only one</u> number corresponding to your answer. For example:

	Never or Almost Never	sometimes	½ of the time	Frequently	Always or Almost Always
1. I ask the teacher or others why I went Wrong on a question or problem	1	2	3	4	5

— If you think you *always* or *almost always* ask the teacher or others why you went wrong on a question or problem, circle the 5.
— If you think you *never* or *almost never* ask the teacher or others why you went wrong on a question or problem, circle the 1
— Or you can choose the number 2, 3, or 4 if one of these seems like a more accurate answer.

2. **How to Change Your Answer**
 If you want to change your answer, cross it out and circle a new number. For example:

3. I ask the teacher or others why I went wrong On a question or problem	1	2	3	4

4. **Course Information**
 Please provide information in the box below. Please be assured that your answers to this questionnaire will be treated confidentially.

Grade/year-level:	Age	M ale	Female

5. **Completing the Questionnaire**
 Now turn the page and please give an answer for every question.

SCALE: 1 = Never or only Rarely: 2 = Sometimes: 3 = Half of the time: 4 = Frequently 5 = Always or Almost Always.

Questions	Scale Circle one number

CCI	I seek to connect what I learn from what happens in the science classroom with out-of-class sciences (e.g. field trips or science visits).	1	2	3	4	5
MEPI	I adjust my plan for a learning task if I am not making the progress I think I should.	1	2	3	4	5
SEI	I know i can understand the most difficult material presented in the readings for this course.	1	2	3	4	5
AWI	I am aware of when I am about to have a learning challenge.	1	2	3	4	5
CC2	I seek to connect what I learn from out-of-school science activities with what happens in the science classroom	1	2	3	4	5
MEP2	I plan to check my progress during a learning task.	1	2	3	4	5
CO1	I adjust my level of concentration, depending on the learning situation.	1	2	3	4	5
MEP8	I try to understand clearly the aim of a task before I begin it.	1	2	3	4	5
SE2	I know I can master the skills being taught in this course.	1	2	3	4	5
MEP7	I evaluate my learning processes with the aim of improving them.	1	2	3	4	5
CC3	I seek to connect what I learn in my life outside of class with science class.	1	2	3	4	5
AW2	I am aware of when I am about to loose track of a learning task	1	2	3	4	5
MEP5	I consider what type of thinking is best to use before I begin a learning task.	1	2	3	4	5
SE3	I'm confident I can do a good job on the assignments and tests in this science class.	1	2	3	4	5
CC4	I seek to connect the information in science class with what I already know	1	2	3	4	5
AW3	I am aware of when I don't understand an idea.	1	2	3	4	5
MEP4	I consider whether or not a plan is necessary for a learning task before I begin that task	1	2	3	4	5
CO2	I adjust my level of concentration depending on the difficulty of the task.	1	2	3	4	5
SE4	I believe I will receive an excellent grade in this course.	1	2	3	4	5

CC5	I seek to connect what I learn from out-of-class science activities (e.g field trips or science museum visits) with what happens in the science class.	1	2	3	4	5
MEP3	I stop from time to time to check my progress on a learning task.	1	2	3	4	5
AW4	I am aware of when I have learning difficulties	1	2	3	4	5
SE5	I'm confident of understanding the most complex material presented	1	2	3	4	5
MEP9	I try to predict possible problems that might occur with my learning.	1	2	3	4	5
CC7	I seek to connect what I learn from what happens in the science	1	2	3	4	5
AW5	I am aware of when I am not concentrating.	1	2	3	4	5
MEP6	I assess how much I am learning during a learning task.	1	2	3	4	5
SE6	I'm confident of understanding the basic concepts taught in this course.	1	2	3	4	5
CO3	i adjust my level of concentration to suit different science subjects.	1	2	3	4	5
CC6	I seek to connect what I learn in other subject areas with science class.	1	2	3	4	5