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Analysis of Metacognitive Orientation for Science Learning Among Senior Secondary School Chemistry Students in Ilorin, Nigeria

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Abstract
Students metacognitive orientations has been reported to be a potent tool in helping students to develop higher-order thinking skills as well as becoming potential problem solvers. This study analyzed the metacognitive orientations for learning science among secondary school students in Ilorin metropolis. The study adopted descriptive research of the survey type. A sample of 520 respondents who were selected through a simple random sampling technique was involved in the study. The instrument used for data gathering was adopted from Thomas, Anderson, and Nashon (2008) entitled Self-efficacy and Metacognitive Learning Inventory- Science (SEMLI-S). Data were analyzed using mean, standard deviation, t-test and ANOVA. Findings from the study revealed that students have high metacognitive orientations for learning Science. Also, class level and students' gender did not significantly influence their metacognitive orientations towards learning science. Furthermore, school type did not significantly influence their metacognitive orientations. The study,

therefore, concluded that students exhibit high metacognitive orientations towards learning Science in Ilorin metropolis. It was recommended among others that teachers should harness the high metacognitive orientations of students to help them improve their learning of Science.

Keywords: Metacognition, Self-efficacy, Metacognitive Orientations and Science Learning.

Introduction

The teaching and learning of Chemistry among senior secondary schools students have been characterized by several challenges. Some of these challenges are teacher-related such as teachers' PCK, attitude and efficacy towards teaching among others. However, these challenges are not limited to teachers alone. Some other factors that influence the teaching and learning of Chemistry are associated with students some of which are students' attitude, their study habits, goal orientations, awareness of their metacognition among others. Metacognition has been an important aspect of educational research as students who are aware of their metacognition tends to be better learners and as such had better achievement in learning activities since they are equipped with information about their cognition. Metacognition as explained by Flavel (1979) and Brown(1987) refers to the knowledge about and regulation of one's cognition.

Metacognition is a term that refers to having knowledge about ones' cognitive process and it plays a major role in learning. It supports the development of students' life-long problem-solving, collaboration and critical thinking skills (Arias, 2017). McFarland (2013), posited that metacognitive aware learners tend to be strategic and perform better in academic tasks than the unaware learners. Therefore, when learners use regulatory metacognitive skills, they do better at paying attention, use learning strategies more effectively, are more aware of when they are not comprehending what they are trying to learn (Schraw & Dennison, 1994). Hence, the awareness of the metacognitive orientations of students should be accorded maximum attention by teachers and students. Therefore, this study investigated senior secondary school students' metacognitive orientations for learning Science.

Purpose of the Study

The present study investigated;

1. Senior secondary students' metacognitive orientation for Science learning.
2. The difference in metacognitive orientation for Science learning among senior secondary school students based on gender.
3. The difference in metacognitive orientation for Science learning among senior secondary school students based on class level.
4. The difference in metacognitive orientation for Science learning among senior secondary school students based on school type.
5. The interaction effect among gender, class level, school type and students' metacognitive orientations for Science learning.

Research Questions

1. What is senior secondary students' metacognitive orientation for Science learning?
2. Do secondary school students differ in their metacognitive orientation to learning Science based on gender?
3. Does class level influence the secondary school students' metacognitive orientation to learning Science?
4. Do the secondary school students differ in their metacognitive orientation to learning Science based on school type?
5. Is there an interaction effect among gender, class level, school type and students' metacognitive orientations for Science learning?

Hypotheses

$H_0$1: there is no significant difference in the metacognitive orientation to learning of science of secondary school students based on gender.

$H_0$2: there is no significant difference in the metacognitive orientation to learning of science of secondary school students based on class level.

$H_0$3: there is no significant difference in the metacognitive orientation to learning of science of secondary school students based on school type.

$H_0$4: there is no significant interaction effect among the three variables that is, class, school type and gender.

Review of Related Literature

Metacognition has been one of the variables that influence students' achievement in science. Chantharanuwong, Thatthong, Yuenyong, and Thomas (2012) posited that metacognition plays a major role in learning, therefore; teachers should support learners to develop it. This will enable them to develop higher-order thinking skills which are necessary to develop students' problem-solving skills. Studies have been conducted to explore students' metacognitive orientations of the science classrooms (Chantharanuwong *et.al.* 2012; Jayapraba & Kanmani, 2013).

Chantharanuwong *et.al.* (2012) explored the metacognitive orientation of science classrooms in Thailand. The study involved 1,376 grade 10 to 12 students and the perception of the classroom was sought from the students using the metacognitive learning scale-Science (MOLES-S). Data gathered from the study were analyzed using mean, standard deviation and one-way Analysis of Variance (ANOVA). Findings from the study revealed that respondents are sufficiently oriented to developing and enhancing metacognition. It was also revealed that no significant difference in the metacognitive orientation of science classrooms as perceived by students based on their school, grade, gender and age. However, students expressed insufficient orientations in dimensions related to "students' voice" and "students' distributed control" in science classrooms. In another study by Jayapraba and Kanmani (2013) investigated the effects of inquiry-based learning and cooperative learning on students' metacognitive awareness in Science classrooms. The study adopted a quasi-experimental design involving three groups and a standardised tool developed by Schraw and Dennision (1994) which contained 52-items. The instrument was used to measure students' metacognitive orientations among the three groups. Data gathered was analyzed using mean, standard deviation, t-test. Findings from the study revealed that students in the cooperative learning group received higher metacognitive awareness compared to other groups and it was concluded that students could gain metacognitive skills through a science lesson through a constructivist approach.

In a similar study, Pimvichai, Yuenyong, Thomas and Art-in (2015), determined the metacognitive orientation of the teaching and learning environments in physics classrooms between urban and rural schools. The study involved grade 10th students in two urban and two rural schools in Khonkaen province, Thailand. The study involved both quantitative and qualitative research (mixed methods) and a sample of 190 respondents in 10th grade was sampled in the study. The instrument was adapted from Thomas (2003) entitled Metacognitive Orientation learning Environment Scale- Science (MOLES-S) which contained 35 items in seven subscales with five items in each of the subscales. The classrooms were observed by a non-participant researcher for six months, then a semi-structured interview was conducted with twenty students (five representatives from each school) The survey revealed that students in the Thai physics classrooms lack metacognition.

A different study by Ajaja and Agboro-Eravwoke (2017) investigated the collection and analysis of students metacognitive orientations for Science learning in Delta State, Nigeria. The study considered variables such as class level and gender. Descriptive research of the survey type was adopted for this study and a sample of 705 was drawn from the entire population. The instrument utilized was the Self-Efficacy and Metacognition Learning Inventory-Science

(SEMLI-S). Data from the study were analysed using a t-test and ANCOVA. Findings from the study revealed that the metacognitive orientations of respondents in all groups and sub-scales fell within the rating of half of the time used. Furthermore, findings showed that students varied in their metacognitive orientation in all the subscales and that higher-level students outscored the lower level students in all the sub-scales while male students significantly outscored their female counterparts in constructs related to "learning risk awareness" and "control of concentration."

In a more recent study, Merchan, Huertas and Ugarte (2020) analysed the relationship between metacognitive skills, gender and level of schooling of high school students in Colombia. The study involved a sample of 319 students who are in grades 6 to 11. The study adopted the use of metacognitive awareness inventory (MAI) and data gathered were analysed using ANCOVA. Findings from the study revealed that there is no significant difference in the development of metacognitive skills based on students' gender. However, a significant difference exists in the development of metacognitive skills across grade levels in favour of 6th grade learners.

Methodology

The study was descriptive and of the survey type. The survey type was considered appropriate for this study as the research utilises a self-report instrument (questionnaire) which enabled respondents to give their report on their metacognitive awareness. The population for this study consisted of all senior secondary school students in Ilorin metropolis who offers Physics, Chemistry and Biology. A sample of five hundred and fifty students (550) was randomly selected and a total of five hundred and twenty (520) valid responses was obtained. The responses obtained include 242 students from private schools and 278 from government-owned schools. The sample represented 181, 188 and 151 SS1, SS2 and SS3 students respectively. While 266 males and 254 females were represented in the valid responses. The instrument used for data collection was adopted by Thomas, Anderson and Nashon (2008). The instrument was structured on a five-point Likert scale of 1= never, 2= sometimes, 3= half of the time, 4= frequently and 5=always. The instrument had been earlier validated by Thomas et al. (2008) but needs to be revalidated since it was adopted in another environment. The face and content validity was carried out by giving the instrument to three experts in Science education while the internal consistency reliability was done by administering the instrument to twenty respondents who did not form part of the sample but possess similar characteristics with the sample. The reliability was calculated using Cronbach Alpha and a reliability coefficient of 0.82 was obtained. Hence, the instrument was considered reliable and was adopted in this study. Data generated from the study were analysed using mean, standard deviation, t-test and ANOVA.

Results

The respondents involved in the study were 520 secondary school students of which 242 were in private school and 278 were in public secondary schools. The students were 181, 188 and 151 in SS1, SS2 and SS3 classes respectively. Also, there were 266 males and 254 females in the study.

Research Question 1: What are senior secondary students' meta-cognitive orientations for Science learning?

Table 1: Respondents' Metacognitive Orientation to Science Learning

S/N	Items	Mean	*SD*
	Constructivist-Connectivity		
1	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.	3.14	1.31
2	I seek to connect what I learn from out-of-school Science activities with what happens in the Science classroom	3.27	1.31
3	I seek to connect what I learn in my life outside of class with Science class	3.29	1.35
4	I seek to connect the information in Science class with what I already know	3.63	1.32
5	I seek to connect what I learn from out-of-class Science activities (e. g. field trips or Science museum visits) with what happened in Science class	3.07	1.35
6	I seek to connect what I learn in other subject areas with Science class	3.32	1.33
7	I seek to connect what I learn from what happens in the science class	3.38	1.37
	Average	**3.30**	**1.33**
	Monitoring, Evaluation and Planning		
8	I adjust my plan for a learning task if I am not making the progress I think I should	3.40	1.38
9	I plan to check my progress during a learning task	3.74	1.19
10	I stop from time to time to check my progress on a learning task	3.55	1.28
11	I consider whether or not a plan is necessary for a learning task before I begin that task	3.36	1.30
12	I consider what type of thinking is best to use before I begin a learning task	3.75	1.27
13	I assess how much I am learning during a learning task	3.70	1.30
14	I evaluate my learning processes to improve them	4.00	1.18

15	I try to understand clearly the aim of a task before I begin it	3.93	1.16
16	I try to predict possible problems that might occur with my learning	3.47	1.33
	Average	**3.65**	**1.26**
	Self-Efficacy		
17	I know I can understand the most difficult material presented in the readings for this course	3.78	1.35
18	I know I can master the skills being taught in this course	4.04	1.17
19	I'm confident I can do a good job on the assignments and tests in this Science class	3.96	1.22
20	I believe I will receive an excellent grade in this course	4.21	1.13
21	I'm confident of understanding the most complex material presented	3.80	1.23
22	I'm confident of understanding the basic concepts taught in this course	3.93	1.18
	Average	**3.95**	**1.21**
	Learning Risks Awareness		
23	I am aware of when I am about to have a learning challenge	3.33	1.36
24	I am aware of when I am about to lose track of a learning task	3.32	1.26
25	I am aware of when I don't understand an idea	3.72	1.31
26	I am aware of when I have learning difficulties	3.80	1.28
27	I am aware when I am not concentrating	3.81	1.35
	Average	**3.59**	**1.31**
	Control of Concentration		
28	I adjust my level of concentration depending on the learning situation	3.68	1.31
29	I adjust my level of concentration depending on the difficulty of the task	3.61	1.31
30	I adjust my level of concentration to suit different Science subjects	4.00	1.24
	Average	**3.76**	**1.28**
	Overall	**3.65**	**1.27**

It is revealed in Table 1 that the respondents have a high metacognitive orientation to science learning because the overall mean value of the items on the Table (M=3.65) is greater than 3.0, which is the average benchmark. Hence, a mean value greater than or equal to 3.0 signifies a high meta-cognitive orientation while a mean value less than 3.0 translate to low metacognitive orientations to Science learning. It can be inferred from Table 1 that the self-efficacy subscale had the highest means value (M=3.95) while the constructivist-connectivity subscale had the lowest mean value (M=3.30).

Research Question 2: Do secondary school students differ in their metacognitive orientation to learning science-based on school type?

$H_0$1 : there is no significant difference in the metacognitive orientation to learning of Science of secondary school students based on school type.

It can be inferred from Table 2 that senior secondary school students differ in their metacognitive orientation to learning science based on school type. Table 2 shows that there is a significant difference between the private secondary school students metacognitive orientation to Science learning (M = 110.92, SD = 17.25) and that of the public school students (M = 107.36, SD = 22.30) since the p-value is equal to 0.05, it means there was a significant difference between the private and public secondary school students' metacognitive orientation to Science learning in favour of private school students which has a higher mean of 110.92, therefore the null hypothesis formulated was rejected ($t_{(518)}$ = 2.01, p =0.05).

Table 2: Independent t-test Analysis of Respondents' Meta-cognitive Orientation Based on their Class

SchType	*N*	Mean	Std. Deviation	*t*	*Df*	*p*	Decision
Private	242	110.92	17.25	2.01	518	0.05	sig.
Public	278	107.36	22.30				

Research Question 3: Do secondary school students differ in their metacognitive orientation to learning science based on gender?

$H_0$2: There is no significant difference in the metacognitive orientation to learning of Science of secondary school students based on gender.

Table 3: Independent t-test Analysis of Respondents' Metacognitive Orientation Based on Gender

Gender	N	Mean	Std. Deviation	*t*	*Df*	*P*	Decision
Male	266	108.61	18.92	-0.46	518	0.64	Not significant
Female	254	109.44	21.42				

Table 3 reveals a slight difference in senior secondary school students metacognitive orientation to learning of science based on gender with the female students having a higher mean score (M = 109.44, SD = 21.42) than their male counterparts (M = 108.61, SD = 18.92). An independent t-test was conducted to determine whether the difference was significant. It was revealed that there is no significant difference in the meta-cognitive orientation of male and female students in learning science ($t_{(518)} = -0.46, p = 0.64$) since the p-value is less than 0.05 hence, the null hypothesis is not rejected.

Research Question 4: Does class level influence the secondary school students' metacognitive orientation to learning Science?

$H_0$3: There is no significant difference in the meta-cognitive orientation to learning of Science of secondary school students based on class

Table 4 shows that there was no significant difference between the class means as determined by one-way ANOVA ($F_{(2,517)} = 0.74$, $p = 0.47$. Since the p-value is greater than 0.05, it means there was no significant difference in the metacognitive orientation of the respondents to Science learning based on their class level. Therefore, the null hypothesis formulated was not rejected. Hence, the class level did not influence the senior secondary school students' metacognitive orientation to learning Science.

Table 4: ANOVA of Respondents' Metacognitive Orientation to Science Learning Based on Class Level

Meta-cognitive Orientation	**Sum of Squares**	***df***	**Mean Square**	***F***	**Sig.**
Between Groups	604.009	2	302.00	.74	.47
Within Groups	210437.86	517	407.03		
Total	**211041.87**	**519**			

Research Question 5: Is there an interaction effectamong class, school type and gender?

$H_0$4: There is no significant interaction effect among the three variables that is, class, school type and gender.

Table 5 reveals a three-way ANOVA consisting of 520 respondents to analyse the interaction effect of class, school type and gender of senior secondary school students' meta-cognitive orientation to Science learning. It can be deduced from the table that there was no significant interaction among the three variables, ($F_{(2, 508)} = 0.280$, $P = 0.756$. since the P-value is greater than 0.05, it means there was no significant interaction among the three variables. Hence, the null hypothesis formulated was not rejected.

Table 5: Three-way ANOVA of Interaction Effect Among Class Level, School Type and Gender

Source	Type Sum Squared	III *Df* of	Mean	*F*	Sig. Eta	Partial Eta Squares
Corrected Model	9405.183[a]	11	855.017	2.154	.016	.045
Intercept	6071518.150	1	6071518.150	15296.478	.000	.968
schtype	1889.608	1	1889.608	4.761	.030	.009
class	691.093	2	345.546	.871	.419	.003
Gender	248.503	1	248.503	.626	.429	.001
schtype * class	2189.565	2	1094.782	2.758	.064	.011
schtype * Gender	2225.670	1	2225.670	5.607	.018	.011
class * Gender	2541.588	2	1270.794	3.202	.042	.012
schtype * class * Gender	221.921	2	110.961	.280	.756	.001
Error	201636.694	508	396.923			
Total	6390906.000	520				
Corrected **Total**	**211041.877**	**519**				

a. R Squared = .045 (Adjusted R Squared = .024)

Discussion

Findings from this study revealed that students exhibit high metacognitive orientations towards Science learning. It was revealed that students recorded highest in the self-efficacy construct and had least in the constructivist connectivity construct. This implies that students exhibit confidence and belief in their capacity to excel in learning Science. This finding supports the findings of Chantharanuwong et. al (2015) who reported that students are sufficiently oriented towards developing metacognition. However, this finding is contrary to the findings of Pimvichai et. al (2015) who reported that Physics students in Thailand lack metacognitive orientations towards learning. Findings also indicated that female students had higher metacognitive orientations for learning Science than their male counterparts although the difference was not significant. This signifies that students' are similar in their metacognitive orientations based on their gender. These findings, however, is similar to those of Merchanet. al (2020) who also reported that there is no significant difference in students' metacognitive skills based on gender. However, this finding is contrary to the findings of Ajaja and Agboro-Eravwoke (2017) who reported that male students outscored their female counterparts in metacognitive orientation constructs.

It was further revealed from the findings of this study that students' class level did not significantly influence their metacognitive orientations towards Science learning. This could be attributed to the fact students have shared a similar experience in terms of their learning environment. This finding is similar to those of Chantharanuwong et. al (2015) and Merchan et. al (2020) who in different studies reported that students' grade level does not influence students' metacognitive orientations towards learning Science. However, it is contrary to those of Ajaja and Agboro-Eravwoke (2017) who reported that lower-level students outscored their counterparts in their metacognitive orientations towards learning Science.

Findings from this study also revealed that students in private schools had higher metacognitive orientations than their counterparts in public secondary schools. This could be a result of different school administrative differences that could influence their learning environment. These findings support of theThesedings of Chantharanuwong et. al (2015) who also reported that grade level as well as age of students does not significantly influence their metacognitive orientation. Furthermore, the findings from this study also revealed that there is no significant interaction among variables such as gender, school type and students' class level on their metacognitive orientations. This implies that students had high metacognitive orientations towards Science learning irrespective of their gender, class and school type.

Conclusion

Based on the findings from this study, it can be concluded that senior secondary school students have a high metacognitive orientation towards learning Science. Furthermore, students' class level and gender did not significantly influence students' metacognitive orientation towards learning Science. However, school types have a significant influence on students' metacognitive orientation towards learning science. Also, there was no significant interaction effect among variables such as gender, school type and class level on students' metacognitive orientation towards Science learning.

Recommendation

It was recommended that teachers should harness the opportunity of high metacognitive orientations of learners to improve students' achievement towards learning Science. Since class level and gender did not influence students' metacognitive orientations towards learning. Educators must deploy constructivist instructional strategies to help students learn Science better irrespective of their class and gender. Furthermore, it was recommended that public school teachers should assist learners more to improve their metacognitive orientation towards learning Science.

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