Influence of Meta-cognition, Self-efficacy, and Self-regulated Learning on Students' Achievement in Biology in Ibadan, Nigeria

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Abstract

Meta-cognitive knowledge and skills play a prominent role in students' learning, retention, and overall success in science and non-science related fields. Proper utilization of students' meta-cognition assists in regulating their learning and building self-confidence in the learners. This, in turn, could contribute to self-learning for meaningful understanding of biological concepts. Hence, the need to explore the influence of meta-cognition, self-efficacy, and self-regulated strategies on the achievements of biology students in Ibadan North, Nigeria. Other specific purposes addressed in the study were (i) influence of meta-cognition, self-efficacy, and self-regulated learning on students' achievement; and the relationship among meta-cognition, self-efficacy, and self-regulated strategies. The study adopted a descriptive research design of a survey type. Three research instruments utilized for data collection were the meta-cognition scale, the self-efficacy scale, and the self-regulated strategy scale. The reliabilities of the instruments were determined using Cronbach's alpha; the reliability values of 0.86, 0.82, and 0.80, respectively, were obtained. The study found that meta-cognition does not significantly influence students' achievement in biology, whereas a significant difference existed between students' achievement in biology and (i) self-efficacy, and (ii) self–regulated strategies. The study also revealed that a relationship existed among meta-cognition, self-efficacy, and self-regulated learning strategies. The study recommends that biology students, in light of the results, should be exposed to different types of meta-cognitive skills, and they should be exposed to tasks and questions that can boost their self-efficacy, among others.

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Introduction

The major goal of 21st century education is to enrich students with knowledge in a given field of study, and to tutor them toward acquisition of meta-cognitive, self-efficacy skills and for self-regulated learning (FRN, 2013). Rajagopal (2008) defined meta-cognition as a form of cognition, which involves active control of cognitive processes. Jia, Li and Cao (2019) defined it as the knowledge and regulation of one's own cognitive processes, which are desirable for creative thinking. Jia et.al, (2019) further stressed that meta-cognition plays a significance role in learning, memory, decision making, and other higher cognitive processes. This implies that meta-cognition is a psychological construct that describes students' reasoning, their awareness, as well as the control of the reasoning.

Research Problem

Biology is crucial to national development; despite the importance, students' performance in the subject in internal and external examinations needs improvement, as reported by May/June chief examiners' report of the West African Examination Council (WAEC, 2016). One of the contributing factors is lack of poor meta-cognitive skills to regulate their learning processes; this reasserted the finding of Mohammed (2022) that poor knowledge of reading comprehension is unconnected to absence of meta-cognition strategies. Wang, Zhang, and Hamilton (2023) were of the views that good meta-cognition cannot be separated from enhanced learning and better achievement.

This study found a clearer view of how meta-cognition influences academic achievement in biology and also considered other important constructs such as self-efficacy and self-regulated strategies in Ibadan North, Nigeria.

Research Focus

The primary intent of this study is to alleviate problems encountered by students in learning biology, improve students' conceptual learning of biology concepts, as well as improve their career prospects for studying biology-related fields in tertiary institutions; this will in turn lead to improved manpower for national development.

Research Aims and Questions

This study investigated the influence of meta-cognition, self-efficacy, and self-regulated strategies on biology students'

learning in Ibadan North, Nigeria. Specifically, this study explored the:

1. influence of meta-cognition on academic achievement of senior secondary students in biology.
2. influence of self-efficacy on academic achievement of senior secondary students in biology.
3. influence of self-regulated strategies on academic achievement of senior secondary students in biology.
4. relationship among meta-cognition, self-efficacy, and self-regulated strategies on academic achievement of senior secondary students in Biology.
5. influence of students' meta-cognition on academic achievement in Biology.
6. how gender influences students' self-efficacy and academic achievements in Biology.
7. gender influence on students' self-regulated strategies and academic achievements in Biology.

The corresponding research questions are:

1. What influence does meta-cognition have on the academic achievement of senior secondary students in Biology?
2. What is the influence of self-efficacy on the academic achievement of senior secondary students in Biology?
3. Does self-regulated strategies influence the academic achievement of senior secondary students in Biology?
4. What influence does gender have on students' meta-cognition and academic achievements in Biology?
5. What influence does gender have on students' self-efficacy and academic achievements in Biology?
6. What influence does gender have on students' self-regulated strategies and academic achievements in Biology?
7. What is the relationship among meta-cognition, self-efficacy, and self-regulated strategies on the academic achievement of senior secondary students in Biology?

The following null hypotheses were formulated in line with the research questions and tested at the 0.05 level of significance.

- Ho_1: Meta-cognition does not significantly influence senior secondary school students' achievement in biology.
- Ho_2: Self-efficacy does not significantly influence senior secondary school students' achievement in biology.
- Ho_3: Self-regulated strategies do not significantly influence senior secondary school students' achievement in biology.
- Ho_4: Gender does not significantly influence students' meta-cognition and academic achievement in biology.
- Ho_5: Gender does not significantly influence students' self-efficacy and academic achievement in biology.
- Ho_6: Gender does not significantly influence students' self-regulated strategies and academic achievement in biology.
- Ho_7: There is no significant relationship among senior secondary students' meta-cognition, self-efficacy beliefs, self-regulated strategies, and their academic achievement in biology.

Research Methodology

The study employed descriptive research of a survey type. This research type was adopted owing to the fact that a questionnaire was utilised in soliciting information on meta-cognition, self-efficacy, and self-regulated strategies from secondary school students in Ibadan North. The names of schools in the L. G. A. were run through the computer software

(Ms Excel) for simple random sampling to ensure representation of the population.

The researcher presented the letter of introduction, signed by the Head of Department of Science Education, University of Ilorin, Ilorin, Nigeria, and informed consent forms were given to the students before the administration of the instruments. The introduction letter is to inform the school of the purpose of the visit, while the informed consent form for the students sought their rights to volunteer; the purpose, procedure, risks, benefits, and confidentiality of the research were also stated. The study did not intend to reflect negatively or expose the participants or their teachers to risks of any form, but to enhance the students' learning and metacognitive awareness in biology and boost their self-efficacy, which can make them become self-regulated learners.

Participants

Ten schools were picked randomly from which twenty-five (25) students who were currently in their senior secondary school II (SSS2) and were willing to participate in the study were chosen to make 250 respondents. The researcher decided to engage students in their penultimate year because the variables of focus (meta cognition, self-efficacy, and self-regulated strategies) are essential particularly for students who are preparing to take the final exam for future university studies.

Instrument and Data Collection

The data were collected with the aid of three validated instruments, namely, the Meta cognition, Self-Efficacy and Self-regulated Strategies Questionnaire (MSSQ) and the Biology Achievement Test (BAT). The first instrument, the Meta cognition, Self-Efficacy and Self-Regulated Strategies Questionnaire (MSSQ), contained three sections: A, B, and C. Section A requests basic information about the respondents, such as gender. Section B consists of a Meta cognitive Questionnaire modified from the Meta cognitive Awareness Inventory for Teachers (MAIT) developed by Balcikanli (2011).

The MSSQ consists of 81 questions designated to capture two broad dimensions of self-regulation: motivation and learning strategies. Responses were provided on a 7-point continuous Likert-type scale anchored by 1 (not at all true of me) and 7 (very true of me).The learning strategies section will be used, owing to the fact that the study will focus on cognitive and management skills.

The Biology Achievement Test (BAT) was a compilation of relevant biology questions designed by the researchers. The content validity, clarity, sentence structure, and comprehensiveness were determined by two biology education lecturers from the Department of Science Education, two (2) educational psychologists from the Department of Counseling Education, and one (1) experienced biology teacher. Reliability indices of 0.86, 0.82, and 0.80, respectively, were obtained using Cronbach alpha techniques. The MSSQ and the BAT were administered during the normal biology class hour so as not to disrupt the classroom activities.

Analysis of Data

Mean and descriptive statistics were used in answering the research questions. Research hypotheses 1-3 were analyzed using linear regression, research hypotheses 4-6 were analyzed using ANCOVA, while research hypothesis 7 was tested using the Pearson Product Moment Correlation at the 0.05 level of significance.

Data Analysis Research Results

Table 1 illustrates the number of male and female students who were involved in the study. Demographic characteristics of the participants revealed that more female students participated in the study against their male counterparts.

Table 1. *Demographic Information of Participants*

	Frequency	Percent	Valid Percent	Cumulative Percent
Male	101	40.40	40.40	40.40
Female	149	59.60	59.60	100.00
Total	250	100.00	100.00	

- **Research Question 1:** What influence does meta-cognition have on senior school students' achievement in Biology?

Table 2 illustrates that most students use meta-cognitive strategies, considering the mean score (3.02), which indicated that students are using meta-cognitive strategies. The mean score of students' achievement was (8.65).

Table 2. *Descriptive Statistics of Meta-cognition and Achievement*

Variables	N	Mean	SD
Meta-cognition	18	3.02	0.76
Achievement	15	8.65	2.15

Research Question 1 gave rise to Hypothesis 1.

- **Hypothesis 1:** Meta-cognition does not significantly influence senior secondary school students' achievement in biology.

Table 3 shows (R= 0.19; $p > 0.05$), since $p > 0.05$, it implies that the hypothesis was not rejected, hence meta-cognition does not significantly influence students' achievement in biology.

Table 3. *Regression Analysis of Meta-cognition and Achievement*

Model		Sum of Squares	df	Mean Square	F	Sig.
Ach*	Meta- cognition	476.75	18	26.49	1.31	0.19
	Residual	4684.28	231	20.28		
	Total	5161.02	249			

- **Research Question 2:** What is the influence of self-efficacy on senior school students' achievement in Biology?

The Self-efficacy mean score (5.48) and Achievement mean score (8.65) of students were presented in Table 4, indicating that most of the students responded positively to the self-efficacy scale. The detailed analysis is shown in Table 5.

Table 4. *Descriptive Statistics of Self-Efficacy and Achievement*

Variables	N	Mean	SD
Self-Efficacy	8	5.48	1.01
Achievement	15	8.65	2.15

- **Hypothesis 2:** Self-efficacy does not significantly influence senior secondary school students' achievement in biology.

Regression analysis in Table 5 (R= 0.04; $p < 0.05$) revealed that self-efficacy significantly influences students' achievement in biology. Hence, hypothesis two was rejected.

Table 5. *Regression Analysis of Self-Efficacy and Achievement*

Model		Sum of Squares	df	Mean Square	F	Sig.
Ach*	Self-Efficacy	327.51	8	40.94	2.04	0.04
	Residual	4833.51	241	20.06		
	Total	5161.02	249			

- **Research Question 3:** What is the influence of self-regulated strategies on the academic achievement of senior secondary students in Biology?

The self-regulated strategies mean score (5.12) and achievement mean score (8.65) of students were presented in Table 6, indicating that most of the students often use self-regulated strategies when learning biology. The detailed analysis is shown in Table 6.

Table 6. *Descriptive statistics of Self-Regulated Strategies and Achievement*

Variables	N	Mean	SD
Self-Regulated	26	5.12	1.69
Achievement	15	8.65	2.15

- **Hypothesis 3:** Self-regulated strategies do not significantly influence senior secondary school students' achievement in biology

Regression analysis result of Table 7 (R= 0.00; $p<0.05$) indicated that self-regulated strategies significantly influence students' achievement in biology. Hence, hypothesis three was rejected.

Table 7. *Regression Analysis of Self-Regulated Strategies and Achievement*

Model		Sum of Squares	df	Mean Square	F	Sig.
	Self-Reg	852.55	19	44.87	2.40	0.00
Ach*	Residual	4289.46	229	18.73		
	Total	5142.01	248			

- **Research Question 4:** What influence does gender have on students' meta-cognition and academic achievements in Biology?

Table 8 shows mean scores and standard deviation scores of male and female students' achievement in biology, with the male mean score (9.56) slightly higher than the female mean score (8.17). The table also reveals the mean scores of meta-cognition of male (2.84) and female (2.96) students, with the female mean score slightly higher than the male. This shows that, though females use metacognitive skills more than male students, the male students outperformed them on the biology achievement test.

Table 8. *Descriptive Statistics of Gender, Meta-cognition and Achievement*

	gender	N	Mean	Std. Deviation	Mean difference
Achievement	male	101	9.56	3.25	
	female	149	8.17	2.85	1.39
Meta-cognition	male	101	2.84	.81	
	female	149	2.96	.80	0.12

- **Research Hypothesis 4:** Gender does not significantly influence students' meta-cognition and academic achievement in biology.

Result of Analysis of Covariance (ANCOVA) (0.87; p>0.05) revealed that gender does not significantly influence students' meta-cognition and achievement. Hence, hypothesis 4 was not rejected. This implies that gender does not influence students' meta-cognition and achievement in biology.

Table 9. *Showing Analysis of Covariance for Gender and Meta-cognition*

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	Hypothesis	23216.78	1	23216.78	324.74	.04
	Error	71.49	1	71.49		
Meta-cognition	Hypothesis	37.10	3	12.37	2.445	.24
	Error	15.15	3	5.05		
gender	Hypothesis	71.49	1	71.49	8.00	.01
	Error	145.60	16.29	8.94		
Meta-cognition * gender	Hypothesis	15.15	3	5.05	.24	.87
	Error	4999.36	242	20.66		

- **Research Question 5:** What influence does gender have on students' self-efficacy and academic achievements in Biology?

Table 10 shows the mean scores and standard deviations of male and female students' achievement in biology, with the male mean score (9.56) slightly higher than the female mean score (8.17). The table also reveals the mean scores of self-efficacy beliefs of male (4.40) and female (4.66) students, with the female mean score lightly higher than the male. This shows that, though female students have slightly higher self-efficacy beliefs than male students, the male students outperformed them on the biology achievement test.

Table 10. *Descriptive Statistics of Gender, Self-Efficacy and Achievement*

	gender	N	Mean	Std. Deviation	Mean Difference
Achievement	male	101	9.56	3.25	1.39
	female	149	8.17	2.85	
Self-Efficacy	male	101	4.40	2.07	
	female	149	4.66	2.09	0.26

- **Research Hypothesis 5:** Gender does not significantly influence students' self-efficacy and academic achievement in biology

Result of Analysis of Covariance (ANCOVA) (0.49; p > 0.05) shows that gender does not significantly influence students' self-efficacy beliefs and achievement. Hence, hypothesis 5 was not rejected. This implies that gender does not have influence on students' self-efficacy beliefs and achievement in biology.

Table 11. *Analysis of Covariance for Gender and Self-Efficacy*

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	Hypothesis	12024.86	1	12024.86	487.49	0.03
	Error	24.67	1	24.67		
Self- Eff	Hypothesis	293.41	6	48.90	2.74	0.12
	Error	106.99	6	17.83		
gender	Hypothesis	24.67	1	24.67	1.30	0.26
	Error	809.78	42.68	18.97		
Self-Eff * gender	Hypothesis	106.99	6	17.83	0.91	0.49
	Error	4645.65	236	19.69		

*Self-Eff= Self-Efficacy, *= And*

- **Research Question 6:** What influence does gender have on students' self-regulated strategies and academic achievements in Biology?

Table 12 shows mean and standard deviation scores of male and female students' achievement in biology, with the male mean score (9.56) slightly higher than the female mean score (8.17). The table also reveals the means of self-regulated strategies of male (4.84) and female (5.41) students, with the female mean slightly higher than the male. This shows that, though female students use self-regulated strategies more than male students, the male students outperformed them on the biology achievement test.

Table 12. *Descriptive Statistics of Gender, Self-Regulated Strategies and Achievement*

	gender	N	Mean	Std. Deviation	Mean Difference
Achievement	* male	101	9.56	3.25	1.39
	female	149	8.17	2.85	
Self-Regulated	* male	101	4.84	1.91	0.61
	female	149	5.41	1.70	

- **Research Hypothesis 6:** Gender does not influence students' self-regulated strategies and academic achievement in biology.

Result of Analysis of Covariance (ANCOVA) (0.41; p>0.05) revealed that gender does not significantly influence students' use of self-regulated strategies and achievement. Hence, hypothesis 6 was not rejected. This implies that gender does not have influence on students' self-regulated strategies and achievement in biology.

Table 13. *Analysis of Covariance for Self-Regulated Strategies and Achievement*

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	**Hypothesis**	30011.99	1	30011.99	394.66	.03
	Error	76.05	1	76.05		
Self-Reg	**Hypothesis**	209.09	6	34.85	1.71	.27
	Error	122.22	6	20.37		
Gender	**Hypothesis**	76.05	1	76.05	3.76	.08
	Error	209.18	10.33	20.25		
Self-Reg * Gender	**Hypothesis**	122.22	6	20.37	1.03	.41
	Error	4690.14	236	19.87		

- **Research Question 7:** What is the relationship among meta-cognition, self-efficacy, and self-regulated strategies on the academic achievement of senior secondary students in Biology?
- **Hypothesis 7:** There is no significant relationship among senior secondary students' meta-cognition, self-efficacy beliefs, self-regulated strategies, and their academic achievement in biology.

Table 14 provides the results of the analysis of hypothesis seven; evidence from the table was some degree of relationship existing between the variables. The study revealed that there was a significant relationship between self-efficacy (r = 0.01; P>0.05) and students' achievement in Biology. Cognitive self-regulation (r = 0.04; P<0.05), resource management (r = 0.00; P<0.05), and achievement. Table 14 shows that there are relationships among meta-cognitive knowledge, self-efficacy, cognitive self-regulation, and meta-cognitive self-regulation. There were relationships among achievement, meta-cognitive self-regulation, and resource management. Relationships existed among cognitive self-regulation, meta-cognitive self-regulation, and resource management. Generally, (P< 0.05), hence, the null hypothesis

was rejected, which means that relationships existed among meta-cognition, self-efficacy, and self-regulated strategies. The table also indicated no significant relationship among achievement, meta-cognitive knowledge, and meta-cognitive regulation (r= 0.71, 0.81; P> 0.05).

Table 14. *Correlation Coefficients among Variables of Study*

Control Variables	1	2	3	4	5	6	7
Test Score	1	0.71	0.81	0.01*	0.04*	0.08	0.00*
Meta-cognitive Knowledge		1	0.05*	0.01	0.01*	0.01*	0.03*
Meta-cognitive Regulation			1	0.05	0.03*	0.04*	0.05*
Self-Efficacy				1	0.00*	0.02*	0.01*
Cognitive Self-regulation					1	0.03	0.00*
Metacog. Self-regulation						1	0.03*
Resource Management							1

(*Correlation is significant at the 0.05 level)

Discussion

Findings of this study indicated that meta-cognition does not influence senior school students' achievement in Biology. This result means that most students were not using higher order thinking skills when learning biology. Most likely, they were not knowledgeable about why, when, and how to use meta-cognitive strategies for learning and problem-solving. This study is in line with Sperling *et al*, 2004, which found no relationship between meta-cognition and academic achievement. This result, however, contradicted some findings which indicated that meta-cognition significantly influenced students' achievements and also promoted students' academic achievement (Achufusi & Mgbemena, 2013; Eluemuno, 2013; Hayat *et al.,* 2020; and Winnie & Azevedo, 2022).

Findings on self-efficacy indicated that senior school students' achievement in biology is being influenced by self-efficacy. This implies that most students believe in their own ability to complete tasks and achieve their goals; they are positive-minded about their abilities to succeed regardless of the obstacles or difficulties they encounter while learning biology as a broad and complex subject. The implication of this result is that students are fond of setting higher goals, selecting more challenging tasks, prevailing in the face of difficulties. They often put forth greater effort to successfully complete academic tasks and use different learning strategies to suit the learning of biology. The outcomes of this study corroborate that of (Hayat et al., 2020; Louis and Mistele, 2011; Meng and Zhang, 2023). The finding, however, contravenes that of Bwenvu (2023), in which self-efficacy does not significantly influence students' performance.

Studies on self-regulated strategies indicated that senior school students' achievement in self-regulation. This indicated that most students can regulate their learning process in biology, use resource management strategies to manage and control their environment, and also regulate their learning. This signifies that students are cognizant of their academic strengths and weaknesses and are capable of using various actions to tackle day-to-day challenges encountered in

biology learning. They practice their learning to develop a deep understanding of the subject and exert efforts that will give rise to academic success in biology. This is in agreement with Anayo (2023) and Orimogunje (2014), who found that students who use different self-regulated strategies achieved higher than students who do not use them; this is because self-regulation enables them to set goals, seek help, manage time, self-evaluate, modify their environment, and employ strategies in order to achieve goals. Therefore, students' self-regulation should be boosted by teaching them self-regulated strategy skills because self-regulated learning is teachable.

Findings on the gender influence on meta-cognitive skills found no significant difference in the meta-cognitive skills of men and women. This indicated that students' gender does not determine their possession of meta-cognitive skills. That is, both male and female students are capable of possessing higher order thinking in learning biology and the ability to control their learning process. This result does not deviate from what was found by (Garzon, Bustos, and Lizarazo, 2020). This is against the findings of Alamdari and Bozorgian (2022), in which females had better meta-cognitive awareness than males.

The findings of this study indicated that gender does not significantly influence students' self-efficacy and achievements. This result means that gender does not influence students' feelings of confidence and competency when learning biology. The implication of this result is that both male and female students would be able to pursue their future endeavors in biology despite the difficulty they may face in biology. This study is in line with the findings of Hassan and Parvez (2019), who reported a significant gender influence.

The influence of self-regulated strategies on gender reported no gender influence on self-regulated study. This implies that students' gender (male and female) does not influence learners' use of certain strategies to manage their time and environment, regulate their effort, seek help, and learn with peers. This buttressed Anazifa, Limiansi, and Pratama (2023)'s result that there was no significant difference between gender and self-regulated learning. In another context, Babalola and Nwozu (2022); Liu et al. (2021) established that female students performed significantly better than their male counterparts; Duru, Mba, and Ike (2023) reported that male students achieved higher than their female counterparts when exposed to self-regulated learning.

Findings on relationships among meta-cognition, self-efficacy beliefs, self-regulated strategies, and achievements confirmed that the use of one strategy leads to the use of another, that is, when students become aware and more skilled in meta-cognitive skills, their self-efficacy beliefs are enhanced. Students' feelings of confidence are incorporated in them, enabling them to use various strategies and regulate their learning processes to become self-regulated learners. This study is in line with Wibowo, et al. (2018), who established that self-efficacy has an important role to play in meta-cognition.

Similarly, Aljuaid (2021) explored self-efficacy and self-regulated as predictors of academic motivation among undergraduate students in the United States. The two factors were reported to have a predictive power on students' motivation; and self-efficacy predicted better than self-regulated. This indicates that the two constructs play a prominent role in students' readiness to learn, hence are great determinants of students' performance.

Conclusion

The findings of the study concluded that students' achievement is independent of their meta-cognition and gender, while students' achievement is influenced by their self-efficacy beliefs and self-regulated strategies irrespective of their gender in biology. It was also concluded that relationships existed among students' meta-cognition, self-efficacy beliefs, and self-regulated strategies.

Limitations and Suggestions for Further Study

This limitation might have produced some setbacks that might have influenced the results of this study: The fact that some students, for obvious reasons, attempted one instrument and did not attempt the second instrument had an influence on the study. Since this situation could not be controlled, an attempt was made to overcome this limitation by sorting out the observed scripts, which were discarded in order to get a reliable result. The attitude of some school owners (mostly private schools) also limited the study because the researcher was not afforded the opportunity to conduct the research in most private schools visited.

Attempts were made to solicit their participation in the study, but it was not possible. However, the use of equal numbers of public and private schools would have ensured a more generalized result, but this was not possible in the study. Since the researcher is not using school type as a variable, the researcher used the available schools that were willing to participate in the study.

In the light of the findings of this study, the following propositions were proffered for future research.

The present study involved SSII students in senior secondary schools. Future studies can be improved upon by using a larger student population and by including students in colleges of education, polytechnics, or even primary schools so as to allow for generalization.

Upcoming researchers could include other mediating factors such as the location of schools, home background, motivation, interest, and age of students (other than ability and gender) which could account for the differential effects of instruction in metacognitive skills, self-efficacy beliefs, self-regulation, and achievements should be studied.

The study should be replicated in Nigeria using other sciences and arts-related courses such as Physics, Chemistry, History, and Economics.

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