Cognitive Engagement as a Predictor of Secondary School Students' Academic Achievement in Biology in Onitsha Education Zone

Akachukwe, Ebele Esther; Okoli Josephine Nwanneka

Department of Science Education, Nnamdi Azikiwe University, Awka, Nigeria

ABSTRACT

The study investigated cognitive engagement as a predictor of secondary school students' academic achievement in biology. Two research questions and two null hypotheses guided the study. The study adopted the correlation design. The population of the study comprised 2,461 senior secondary year two (SS2) students offering Biology in Onitsha Education Zone. The sample for the study was 736 students obtained using multi-staged sampling procedure. Cognitive Engagement Questionnaire (CEQ) validated by three experts was used for data collection. The reliability of CEQ was established using Cronbach Alpha to be 0.84. The students' achievement scores in Biology for two terms in 2021/2022 academic session were obtained from the teachers' score inventory and used for the study. The data obtained was analyzed using simple and multiple linear regressions. The findings of the study revealed among others that 0.7% of the variance in achievement in biology was predicted by students' cognitive engagement. Also, achievement scores in Biology were significantly predicted by students' cognitive engagement. It was recommended that teachers should make instructional processes cognitively engaging for the students giving them in-class biology exercises and take-home learning projects and inquiries as well as providing them with scaffolds that can be withdrawn to incite active cognitive processing during learning.

KEYWORDS: cognitive-engagement, achievement, biology predictor

IJTSRD52648

INTRODUCTION

Science generates solutions for problems of everyday life and helps to provide answers to the great mysteries of the universe. Since it is one of the most important channels of knowledge, basic knowledge of science is mandatory for everybody as it makes life easier. This is why science, technology and innovation drive every nation's pursuit of more equitable and sustainable development. One of the science subjects studied at the secondary level of education aside chemistry and physics is Biology.

Biology is one of the most popular science subjects offered by secondary school students in science and non-science discipline and has also been used as a criteria for admission into university education in Nigeria. This notwithstanding, students' achievement has not improved as expected despite the research studies to improve on the implicated factors. Little or no attention has been given to the cognitive engagements in biology and how it influences their achievement in the subject. There is therefore the need to examine other factors relating especially to the students such as cognitive engagement that could predict students' achievement in Biology.

Cognitive engagement has been shown in literature to predict achievement; however, most studies on cognitive engagement focused on students in the university and little or no studies have been conducted on the prediction of achievement in Biology at the secondary level of education. Most of such studies to were not conducted in Anambra state secondary schools in the subject area of Biology. The results of the studies are mixed and the studies have not been conducted widely among secondary school Biology students in Anambra state. It is also not known how cognitive engagement interacts to predict students' achievement in Biology in its dimensions.

The problem of the study is therefore to unravel and change the poor understanding into how cognitive engagement predicts or influences students' achievement in biology.

Student engagement refers to the degree of attention, curiosity, interest, optimism, and passion that students show when they are learning or being taught, which extends to the level of motivation they have to learn and progress in their education (Eric, Peter, Aloka and Benson, 2018). Eric *et al.* noted further that cognitive engagement is the extent to which students' are willing and able to take on the learning task at hand. This includes the amount of effort students are willing to invest in working on the task, and how long they persist. Activities that can describe cognitive engagement include making mind maps, visualisation, association, mnemonics, using clues in reading comprehension, underlining key words, scanning and self-testing and monitoring. For the purpose of this study, the following dimensions of cognitive engagement will be discussed: interactive engagement, active engagement, constructive note-taking and passive engagement. These dimensions of cognitive engagement were extensively described by Shane (2019).

According to Shane (2019), interactive engagement or interactivity with peers references a dialogue between two students in which they add further definition to a course construct via an equally-participatory conversation. Interactively engaged students co-create knowledge. Active engagement as described by Shane (2019) entails focused attention and a basic level of information manipulation (that is underlining or highlighting) and is measure in two dimensions: Active note-taking and active processing. Active note-taking is related to overt activities during note-taking that are indicative of an underlying cognitive state. Shane (2019) further noted that active processing is directly related to students' reports on their own cognition, highlights the focused attention component. Constructively note-taking involves generating knowledge beyond that which is presented to them in a subject. Passive engagement is an orientation towards and receiving from the subject content. Cognitive engagement is also known to predict achievement.

The cognitive engagement of a student plays therefore a significant role in their academic achievement. The needed arises that a study be conducted to determine whether the variations in cognitive engagement could predict achievement in biology. Most studies like those of Mariam, Alireza, Elaheh and Hamidreza (2011), Nagarajah, Chung, Rahmah and Lim (2016) and Ohamobi and Ezeaku (2016) on cognitive engagement were conducted in different subject areas using students at different level of education. The results of the studies are mixed and the studies have not been conducted widely among secondary school Biology students in Anambra state.

Purpose of the Study

The purpose of the study was to investigate cognitive engagement as a predictor of secondary school students' academic achievement in Biology in Onitsha Education Zone. Specifically, the study determined the:

1. Predictive power of students' cognitive engagement on achievement scores in Biology.
2. Relative contribution of the dimensions of cognitive engagement (interactivity with peers, constructive note-taking, active note-taking, active processing and passive processing) to the prediction of students' achievement scores in Biology.

Research Questions

The following research questions guided the study:

1. What is the predictive power of students' cognitive engagement scores on achievement scores in Biology?
2. What are the contributions of the dimensions of cognitive engagement (interactivity with peers, constructive note-taking, active note-taking, active processing and passive processing) to the students' achievement scores in Biology?

Hypotheses

The following null hypotheses were tested at 0.05 level of significance:

1. Students' cognitive engagement is not a significant predictor of their academic achievement scores in Biology.
2. The contributions of the dimensions of cognitive engagement (interactivity with peers, constructive note-taking, active note-taking, active processing and passive processing) to the students' academic achievement scores in Biology are not significant.

Method

The study adopted the correlation design. The area of the study was Onitsha Education Zone of Anambra state which is one of the six education zones in the state. The population of the study was 2,461 senior secondary year two (SS2) students offering Biology in Onitsha Education Zone. The sample for the study is 736 SS2 students offering Biology. The sample was obtained using a multi-stage sampling procedure.

The instrument for data collection was Cognitive Engagement Questionnaire (CEQ). CEQ was adopted from Shane, (2019) who developed the instrument to measure students' cognitive engagement. CEQ is an eighteen item instrument which has five dimensions namely: interactivity with peers, constructive note-

taking, active note-taking, active processing and passive processing. Interactive Engagement or Interactivity with Peers references to a dialogue between two students in which they add further definition to a course construct via an equally-participatory conversation. Interactively Engaged students will co-create knowledge. Constructively note-taking involved generating knowledge beyond that which is presented to them in a subject. Active Engagement requires focused attention and a basic level of information manipulation (i.e. underlining or highlighting) and was measured in two dimensions: Active note-taking and active processing. Active note-taking is related to overt activities during note-taking that are indicative of an underlying cognitive state. Active Processing is directly related to students' reports on their own cognition, highlights the focused attention component. Passive Engagement is an orientation towards and receiving from the subject content. CEQ was designed on a four-point scale of strongly agree, agree, disagree and strongly disagree. Students' achievement for two terms was obtained from the schools' Biology Score folder which is an inventory book where the Biology teachers record the students' academic achievement in Biology each term. The objectives of the study, research questions and hypotheses, CEQ were given to three lecturers in Departments of Science Education and Educational Foundations, Nnamdi Azikiwe University, Awka, for validation.

The validators will be required to vet the items in terms of clarity, plausibility of distractors and suitability for the level of students under study. Their corrections, suggestions and recommendations were effected in the instrument. The reliability of CEQ was established using Cronbach Alpha. The instrument was also administered to the same 40 students used for DAT. The coefficient of internal consistency obtained for CEQ was 0.84. The instruments were administered with the aid of eight research assistants who were briefed about the study and how to administer and collect data using the instruments. Data generated from the study was analysed using simple linear and multiple regressions. The R-value was used to determine the magnitude and direction of relationship while the R-square value was used to determine the variance in achievement that is caused by the predictor variables. The prediction powers and relative contribution was determined using the beta coefficients. The null hypotheses were tested at 0.05 level of significance. In taking decision: whenever Pvalue is less than or equals 0.05 ($P \leq 0.05$) the null hypothesis was rejected and was accepted whenever Pvalue is greater than 0.05 ($P > 0.05$).

Results

Research Question 1: What is the predictive power of students' cognitive engagement scores on achievement scores in Biology?

Table 1: Prediction of Students' Achievement in Biology by Cognitive Engagement

Model	R	R^2	Adjusted R^2	Unstandardized coefficients (b)	Std. Error	Decision
Constant	.082[a]	.007	.005	53.446	12.802	Low positive relationship
Cogn. Eng.				.272		
a. Predictors: (Constant), cognitive engagement						

Table 1 shows a low positive relationship (R = 0.082) exists between students' cognitive engagement and their achievement in biology. The R-Square value of 0.007 indicates that 0.7% of the variance in biology scores is predicted by cognitive engagement.

Research Question 2: What are the contributions of the dimensions of cognitive engagement (interactivity with peers, constructive note-taking, active note-taking, active processing and passive processing) to the students' achievement scores in Biology?

Table 2: Contributions of the Individual Dimensions of Cognitive Engagement in the Prediction of Achievement Scores in Biology

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	51.790	7.304		7.091	.000
Interactivity with Peers	.545	.266	.075	2.052	.040
Constructive note-taking	.682	.302	.083	2.261	.024
Active note-taking	.532	.262	.074	2.029	.043
Active processing	-.571	.262	-.081	-2.176	.030
Passive processing	.438	.268	.060	1.630	.103
a. Dependent Variable: Biology Achievement					

Table 2 shows the standardized beta coefficient which indicates correlation between variables. The unstandardized beta coefficient which shows the prediction powers of each dimension of cognitive engagement which indicates their relative contribution to achievement in biology. The table shows that interactivity with peers has a low positive relationship (R = 0.075) with students' their achievement in biology, constructive note-taking has a low positive relationship (R = 0.083) with achievement in biology, active note-taking has a low positive relationship (R = 0.074) with achievement in biology, active processing has a low positive relationship (R = 0.081) with achievement in biology while passive processing has a low positive relationship (R = 0.060) with achievement in biology. Table 2 also reveals that interactivity with peers contribute 0.545 to achievement in biology whenever a students' interaction with their peers increase by one unit. With a unit increase, constructive note-taking increases achievement in biology by 0.682, active note-taking by 0.532, active process by 0.571 while passive processing increases achievement by 0.438. The order of relative contribution to achievement in biology from the highest to lowest by each dimension of cognitive engagement is; constructive note-taking (0.682), followed by active processing (0.571), interactivity with peers (0.545), active note-taking (0.532) and then passive processing (0.438).

Hypothesis 1: Students' cognitive engagement is not a significant predictor of their academic achievement scores in Biology.

Table 3: ANOVA on Significance of Prediction of Achievement in Biology by Students' Cognitive Engagement

	Model	Sum of Squares	df	Mean Square	F	Sig.
1	Regression	820.598	1	820.598	5.007	.026[b]
	Residual	120303.118	734	163.901		
	Total	121123.716	735			
a. Dependent Variable: Achievement						
b. Predictors: (Constant), Cognitive Engagement						

Table 3 shows that cognitive engagement is a significant predictor of achievement scores in biology $F (1, 734) = 5.007$, $P (0.026) < 0.05$. The null hypothesis was therefore rejected implying that cognitive engagement is a significant predictor of secondary school students' achievement scores in Biology.

Since cognitive engagement is a significant predictor of achievement scores in biology, the regression model $(Y = a + bX)$ for the prediction of achievement score in biology as derived from Table 1, where constant = 53.446 and b value = 0.272 is:

$$BI = 53.446 + 0.272(CG)$$

Where, BI = Biology Achievement and CG = Cognitive Engagement

Hypothesis 2: The contributions of the dimensions of cognitive engagement (interactivity with peers, constructive note-taking, active note-taking, active processing and passive processing) to the students' academic achievement scores in Biology are not significant.

Table 4: ANOVA on Significance of Prediction of Achievement in Biology by the Individual Dimensions of Cognitive Engagement

	Model	Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3192.790	5	638.558	3.953	.002[b]
	Residual	117930.926	730	161.549		
	Total	121123.716	735			
a. Dependent Variable: Biology Achievement						
b. Predictors: (Constant), Passive processing, Interactivity with Peers, Active note-taking, Constructive note-taking, Active processing						

Table 4 shows that all the individual dimension of cognitive engagement jointly predicted the students' achievement scores in biology significantly $F (1, 730) = 3.953$, $P (0.002) < 0.05$. However, data contained in Table 4 shows the significance of the contributions of the individual dimensions of cognitive engagement to the prediction of achievement scores in biology.

Table 4 shows that interactivity with peers is a significant predictor of achievement scores in biology, $t = 2.052$, $P (0.040) < 0.05$, constructive note-taking is a significant predictor of achievement scores in biology, $t = 2.261$, $P (0.024) < 0.05$, active note-taking is a significant predictor of achievement scores in biology, $t = 2.029$, $P (0.043)$

< 0.05, active processing is a significant predictor of achievement scores in biology, t = 2.176, P (0.030) < 0.05 while passive processing is not a significant predictor of achievement scores in biology, t = 1.630, P (0.103) > 0.05. Thus, the significant contributors to the achievement of students in biology in order of significance are constructive note-taking, active processing, interactivity with peers and active note-taking. However, since the joint prediction of all the dimensions of cognitive engagement in the prediction of achievement score in biology is significant, the regression model ($Y = a + bX_1 + cX_2 + dX_3 + eX_4 + fX_5$) for the prediction of achievement score in biology as can be derived from Table 2, where constant = 51.790 and b value = 0.545, c value = 0.682, d value = 0.530, e value = 0.571, f value = 0.438 is:

$$BI = 51.790 + 0.545(IWP) + 0.682(CNT) + 0.530(ANT) + 0.571(AP) + 0.438(PP)$$

Where, BI = Biology Achievement and IWP = interactivity with peers, CNT = constructive note-taking, ANT = active note-taking, AP = active processing, PP = passive processing

Discussion

The study showed that cognitive engagement has a low positive relationship with achievement, and significantly predicts 0.7% of students' achievement score in biology. The only significant contributors to the achievement of students in biology in order of significance are interactivity with peers, constructive note-taking, active note-taking and active processing. Cognitive engagement is necessary for what a student in thinking in the classroom and the extent of distraction they entertain. The result of the study shows that it is important for students to be thinking about the contents, lesson or activities relating to biology during the learning process, if they must attain high achievement in biology. Again, a student may be emotionally and behavioural engaged, but lack of cognitive engagement may lead to poor understanding of learning materials and in turn result in poor academic achievement.

The idea of being cognitively engaged in the learning process explains how much a student can be autonomous because of high self-regulation arising from proper conceptualization of what is taught. At such time, a student is able to search for more information and listen attentively to lesson which facilitates their engagement initiative for every other lesson. This further explains why interactivity with peers significantly predicted biology achievement. Students who are cognitively engaged through interaction with each other co-create knowledge and improve retention because there is understanding, not just mere rote learning.

The understanding garnered from active interaction with others lead to constructive note taking. As the cognitive processes facilitate understanding, students are more able to write down the lesson materials in ways most understanding and easily remembered. As they take constructive notes, they become more active cognitively and behaviourally as well as emotionally. Thus, their robust engagement in the learning at such time incites active note taking which an indication of the active cognitive processes. To maintain stability in the active cognitive engagement and learning going on, students must be actively processing all the learning experiences.

The findings of the study are in line with Nagarajah, Chung, Rahmah and Lim (2016) that students with favourable ratings on their academic engagement in studies tend to do better academically. The findings of the study support the finding of Ohamobi and Ezeaku (2016) that engagement was found to be significantly correlated with achievement. The findings of the study related to the findings of Eric, Peter, Aloka and Benson (2018) that cognitive engagement was a significant predictor of academic achievement among secondary school students studied.

Conclusion

The study concluded that cognitive engagement is significant predictors of students' achievement in Biology. Again, when a student is cognitively engaged by interacting with peers, actively and constructively taking notes and actively processing the learning material, academic achievement in biology is mostly going to be improved.

Recommendations

The following recommendations are made based on the findings of the study:

1. Effort should be made by biology teachers to adopt instructional strategies that facilitate interaction among students and other peers as a way of developing in them the skills of interpersonal and intrapersonal communications.

2. Biology teachers should employ group learning strategies giving students the task of developing active and constructive notes from their discussion and to present them in the general class.

3. Teachers should make instructional processes cognitively engaging for the students by giving them in-class biology exercises and take-home learning projects and inquiries as well as providing them with scaffolds that can be withdrawn to incite active cognitive processing during learning.

References

[1] Eric, W., Peter, J.O. Aloka, & Benson, C.O. (2018). Relationship between cognitive engagement and academic achievement among Keyan secondary school students. *Mediterranean Journal of Social Sciences, 9*(2), 61-72. Doi: 10.2478/mjss-2018-0026.

[2] Maryam, S, Alireza, A., Elaheh, H. & Hamidreza, H. (2011). Motivation, cognitive engagement and academic achievement. *Procedia Social and Behavioural Sciences, 15,* 2406-2410. Doi:10.1016/j.sbspro.2011.04.117

[3] Nagarajah, L., Chung, H.T., Rahmah, H. & Lim, T.M. (2016). The relationship between persistence, academic engagement and academic achievement among postgraduate students of OUM. Retrieved from Open-univesity-malaysia-knowledge-repository.

[4] Ohamobi, I. & Ezeaku, S.N. (2016). Students' engagement variables as correlates of academic achievement in economics in senior secondary schools in Anambra state, Nigeria. *International Journal of Science and Research (IJSR), 5*(5), 473-484.

[5] Shane, A.B. (2019). *An investigation of students' cognitive engagement in the STEM classroom- A compilation of faculty and student perspectives.* Unpublished Dissertation, Oregon State University.