

Secondary School Students' Critical Thinking Ability as Correlate of their Academic Achievement in Biology in Awka Education Zone, Nigeria

Izunna Shedrack NWUBA¹, Sussan Onyebuchi EGWU², Opeyemi Fadekemi AWOSIKA³, Abigail Mgboyibo OSUAFOR⁴

¹Department of Science Education, Nnamdi Azikiwe University, Awka, Nigeria

²Department of Science Education, Nnamdi Azikiwe University, Awka, Nigeria

³Department of Science Education, Nnamdi Azikiwe University, Awka, Nigeria

⁴Department of Science Education, Nnamdi Azikiwe University, Awka, Nigeria

Correspondence: is.nwuba@unizik.edu.ng¹

ABSTRACT

Aim of the Study: The goal of the study was to determine the association between secondary school students' biology academic accomplishment in the Awka Education Zone and their capacity for critical thought. The study was directed by three research questions and three null hypotheses that were assessed for significance at the 0.05 level.

Methods: The study adopted a correlational survey research design. 4755 senior secondary year two (SS2) students constituted the population of the study. Random sampling technique was employed to compose the sample size of (N= 523) SS2 students used in the study. Two instruments, adapted Watson-Glaser Critical Thinking Appraisal (WGCTA) validated by three experts and with a reliability coefficient of 0.71 obtained using Kuder-Richardson formula 21 (KR-21) and Students Achievement Score Proforma in Biology (SASPB), were used for data collection. In order to answer the study questions, data obtained from the respondents with the assistance of two research assistants was analysed using Pearson Product Moment, and t-test for correlation was used to test the null hypotheses.

Findings: The study's conclusions showed a strong correlation between secondary school students' biology academic success and their capacity for critical thought. The study also showed that although there is a statistically significant association for both groups of students, it is more favourable for female students than for male students.

Conclusion: The study came to the conclusion that, regardless of gender, there is a substantial correlation between secondary school pupils' capacity for critical thought and their academic success in biology. Hence, it was recommended among others that biology teachers should adopt innovative approaches in the learning process to foster and promote critical thinking ability of students in schools as this will help improve their academic achievement in biology.

Keywords: Critical Thinking Ability, Academic achievement, Biology.

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Introduction

Biology is one of the science subjects studied in Nigerian secondary schools. Its relationship to Agriculture, in which both studies plants and animals, has made it a major asset for national development as well as management and conservation of resources. Nwuba and Osuafor (2021) defined biology as simply the study of living things and their interaction with each other and their environment. It is that branch of science that studies life and evolution as well as their structures, processes and interactions with each other and their environment (Aloh & Atanna, 2013). Hence, Biology is the branch of science that studies plants and animals in their environment.

It is impossible to overstate the value of biology to the growth of a country. It is likely for this reason that Osuafor and Okonkwo (2013) believed that the interconnectedness of science with other fields such as agriculture, chemistry, geography, mathematics, and physics has resulted in significant advancements in specialised fields such as medicine, pharmacy, food production and processing industries, biotechnology, genetic engineering, agriculture and horticulture, agriculture and environmental protection, as well as tourism. Supporting the premise, Ufommadu and Okoli (2019) stressed that the knowledge of biology enables learners develop not only problem solving and decision-making skills but also understand the relationship between biology and health, agriculture, industry, and life in general. Nwuba and Osuafor (2021) argued that biology is an engaging intellectual journey whose value to man, like science, cannot be over-emphasised in order to summarise the aforementioned importance.

According to Arukoya and Chukwu (2017), biology has a high student enrollment in external examinations when compared to other science disciplines in Nigerian secondary schools. This is consistent with the aforementioned benefits and biology's nature of requiring little to no mathematical computations. Despite the students' perceptions of its popularity and easiness, the percentage of pupils who pass reported throughout time in external exams, such as West African Secondary School Certificate Examinations (WASSCE), has remained unsatisfactory. This agrees with the earlier observations of Osuafor and Okonkwo (2013), Agboghoroma and Oyovwi (2015) and Nwuba and Osuafor (2021), who reported in their various studies, that the academic achievement of biology students in external examinations such as WASSCE and Senior Secondary Certificate Examination (SSCE) has not been satisfactory.

Educational psychologists, science teachers and researchers (Fitriani et al., 2020; Attamah & Okoli, 2021; Egwu & Okigbo, 2021; Nwuba & Osuafor, 2021) have attributed this unsatisfactory performance of students in biology to many factors that interacts and influences the teaching and learning process such as students personal (psychological) variables (self-efficacy, locus of control, interest, creativity, communication skills, critical thinking ability) and environmental variables like teacher-related factors, teaching methods and strategies, unconducive learning environment, non-availability of instructional materials for teaching, absence of equipped biology laboratories in schools, inadequate science equipment for practical lessons, high student-teacher ratio (large class size) and wide content of secondary school biology curriculum.

To enhance performance in biology examinations, many research works have been successfully carried out and published on these environmental variables, prompting education stakeholders and professional bodies such as Science Teachers' Association of Nigeria (STAN) to provide resources as well as organize workshops, conferences, and symposia to educate teachers on how to develop, implement and foster strategies to overcome these environmental factors, yet it is painstaking to note that students' achievement in biology has still not improved significantly over the years. This begs the questions; what else could be the problem? could it be students' personal (psychological) variables in play? Taking cognizance of the above questions, the study sought out to investigate these personal variables, which little attention have been paid to over the years, to see if/how they influence and correlate with students' achievement. Hence, in this study, students' critical thinking ability was investigated to see how it relates to their academic achievement in biology.

Critical thinking, one of the 4Cs (Communication, Critical thinking, Creativity, Collaboration) of STEM (Science, Technology, Engineering and Mathematics), has been recognized as a major tool for problem solving in all aspects of life in the 21st century as it involves employing the cognitive skills of analysis, evaluation, deduction, and induction (Slameto, 2014). It is an intellectually disciplined process that actively and skilfully conceptualises, applies, analyses, synthesises, and/or evaluates knowledge obtained from, or generated by, observation, experience, reflection, reasoning, or communication, according to Lee's definition from 2015. Hence, critical thinking ability can be said to be an innate personal characteristic that enables an individual to analyze, understand and solve his/her everyday problems.

Supporting the definitions above, Fajrianty and Septarini (2016) stressed that critical thinking ability is the key through which students solve their everyday problems as it makes them to be self-explorative. That is, it helps them gain insight into situations, acquire problem solving skills and have self-understanding of the environment. Similarly, Sendaq and Odadas cited in Fitriani, Zubaidah, Susilo and Al Muhdhar (2020) asserted that critical thinking helps students absorb knowledge and improve their academic achievement as they are higher order thinking skills that requires students to explore information to learn. Summarizing the above, David cited in Nwuba and Osuafor (2021) posited that students who fail to develop their critical thinking skills typically suffer with lower academic grades as these abilities needed to develop their reflective thinking that fuses analyzing arguments and generating insights into particular meanings and interrelations are not developed. Taking cognizance of the above assertions, the researcher therefore is suspecting that students critical thinking ability may be a contributing factor to their unsatisfactory achievement in biology and hence, the rationale behind the study.

Academic achievement is the outcome of an educational programme. It refers to an academic position a student occupies in the class relative to the position of others, in the same class, usually assessed by the teacher's use of rating scales, tests and examinations (Anekwe, 2011). Nwuba (2021) defined it as the gain in knowledge of a student which occurs as a result of taking part in a learning activity or programme. Hence, academic achievement maybe defined as a statistic report of a student's performance in an engaged educational (academic) programme. Most studies carried out in Nigeria have asserted that academic achievement of learners depend mostly on learners' hard work and interaction between other personal (psychological) and environmental variables involved in the learning process. In this study therefore, its relationship with students critical thinking ability, a personal variable, was studied irrespective of gender.

Gender is a social construct that differentiates male and female in the society. Nwuba, Egwu and Osuafor (2022) defined it as simply an attribute ascribed to male and female based on biological characteristics. In the context of Education, gender issues are referred to as the difference, both real and perceived, between boys and girls in opportunities and the direction of achievement for either males or females (Westminster Institute of Education, 2006). In recent times, gender related issues in science education have generated serious concerns for science educators judging by the number of studies done to that effect. Still, there is no consensus as to whether it influences and correlates with students' academic achievement and critical thinking ability in biology or not. For instance, While Shahzadi, Nimmi and Khan (2020) reported in their study that although a positive relationship exists between students critical thinking ability and their academic achievement in sciences, the relationship is statistically significant for males and not for females. Taghva, Rezael, Ghaderi and Taghva (2014) and Chiketa and Okigbo (2021) in their own studies revealed that a statistically significant relationship exists between students critical thinking ability and their academic achievement in sciences irrespective of gender.

This inconclusiveness on gender and its relationship to critical thinking and academic achievement calls for further studies. Hence in this study, the relationship between students critical thinking ability and their academic achievement in biology with respect to gender was also studied. It is against this backdrop that the researchers sought out to determine the relationship between secondary school students' critical thinking ability and their academic achievement in biology in Awka Education Zone.

Statement of the Problem

The role of biology in wealth creation and nation building cannot be overemphasized. This is probably why educational psychologists, science teachers and educators have continued the search for variables that could be influenced to improve students understanding of the subject and hence achieve better in external examinations. Of all the identified variables, most researchers have placed emphasis mostly on the environmental variables, such as teaching methods and strategies, the learning environment, instructional materials for teaching, class size and wide content of secondary school biology curriculum, prompting education stakeholders and professional bodies, such as STAN, to provide resources as well as organize conferences, symposia and workshops to educate teachers on the innovative approaches to employ in order to promote and foster learning, while little or no attention has being paid to these students' personal variables like self-efficacy, locus of control, interest, creativity, communication skills, critical thinking ability which in all could be the underlying variables influencing students achievement in the subject. In this light, the study seeks to determine and establish the relationship between secondary school students critical thinking ability and their academic achievement in biology.

Research Questions

The following research questions guided the study

1. What is the relationship between secondary school students critical thinking ability and their academic achievement in biology?
2. What is the relationship between male secondary school students critical thinking ability and their academic achievement in biology?
3. What is the relationship between female secondary school students critical thinking ability and their academic achievement in biology?

Hypotheses

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

1. No significant relationship exists between secondary school students critical thinking ability and their academic achievement in biology.
2. No significant relationship exists between male secondary school students critical thinking ability and their academic achievement in biology.
3. No significant relationship exists between female secondary school students critical thinking ability and their academic achievement in biology.

Methodology

Research design

The research adopted a correlational survey research design.

Population

The 4,755 SS2 pupils at the 62 government-owned secondary schools in the Awka Education Zone, Anambra State, made up the study's population.

Sample Size and Sampling Technique

523 (195 males and 328 females) (N=532) SS2 biology students sampled from the 44 coeducational secondary schools in the zone, using simple random sampling technique, constituted the sample of the study.

Instrument

An adapted version of Watson-Glaser critical thinking appraisal (WGCTA) as well as the Students Achievement Score Proforma in Biology (SASPB) that is, SS2 students' cumulative average scores in biology for first, second and third term in the 2020/2021 academic session, were used for data collection.

Validity

Three experts from the Faculty of Education at Nnamdi Azikiwe University in Awka, Anambra State (two from the Department of Science Education and one from the Department of Educational Foundations, Measurement and Evaluation) validated the modified instrument (WGCTA).

Reliability

The adapted WGCTA was given to a class of 40 students in the Aguata Education Zone, who are not a part of the study, to determine the instrument's reliability. Using the Kuder-Richardson 21 (KR-21) formula, a reliability coefficient of 0.71 was obtained, indicating that the instrument is highly reliable.

Data Analyses Technique

The data obtained with the help of two research assistants were analyzed using Pearson Product Moment coefficient in answering the research questions and t-test for correlation in testing the null hypotheses at 0.05 level of significance. The interpretation of the relationship was based on a range given by Nwana, as cited by Okoye (2015), and is as follows: $r = .00$ no relationship, $r = \pm 0.01$ to ± 0.20 low relationship; $r = \pm 0.21$ to ± 0.50 slight to fair relationship; $r = \pm 0.51$ to ± 0.70 substantial relationship; $r = \pm 0.71$ to ± 0.99 high relationship and $r = \pm 1.00$ perfect relationship. In testing the null hypotheses, reject the null hypotheses if the probability value (P-value) is less than 0.05 alpha level, if otherwise do not reject.

Results

RQ 1: What is the relationship between secondary school students critical thinking ability and their academic achievement in biology?

Table I: *Pearson r on secondary school students critical thinking ability and their academic achievement in biology*

Source of variation	N	Critical Thinking Ability	Academic Achievement	r ²	Remark
Critical Thinking Ability	523	1.00	0.52	0.27	Substantial Positive Relationship
Academic Achievement	523	0.52	1.00		

Adjusted r²=0.26

Data in Table 1 shows a Pearson coefficient (r) of 0.52 indicating that a substantial positive relationship exists between secondary school students critical thinking ability and their academic achievement in biology.

RQ 2: What is the relationship between male secondary school students critical thinking ability and their academic achievement in biology?

Table 2: Pearson *r* on male students' critical thinking ability and their academic achievement in biology

Source of variation	N	Critical Thinking Ability	Academic Achievement	r^2	Remark
Critical Thinking Ability	195	1.00	0.46	0.21	Slight to fair Positive Relationship
Academic Achievement	195	0.46	1.00		

Adjusted $r^2=0.20$

Data in Table 2 shows a Pearson coefficient (*r*) of 0.46 which indicates that a slight to fair positive relationship exists between male secondary school students critical thinking ability and their academic achievement in biology.

Research Question Three: What is the relationship between female secondary school students critical thinking ability and their academic achievement in biology?

Table 3: Pearson *r* on female students critical thinking ability and their academic achievement in biology

Source of variation	N	Critical Thinking Ability (<i>r</i>)	Academic Achievement (<i>r</i>)	r^2	Remark
Critical Thinking Ability	32	1.00	0.55	0.30	Substantial Positive Relationship
Academic Achievement	32	0.55	1.00		

Adjusted $r^2=0.30$

Data in Table 3 shows a Pearson coefficient (*r*) of 0.55 which indicates that a substantial positive relationship exists between female students critical thinking ability and their academic achievement in biology.

Null Hypothesis One: No significant relationship exists between secondary school students' critical thinking ability and their academic achievement in biology

Table 4: *T*-test for significant relationship between secondary school students' critical thinking ability and their academic achievement in biology

Source of Variation	N	Critical thinking ability	Academic Achievement	P-Value	Remark
Critical thinking ability	523	1.00	0.52	0.00	Significant
Academic Achievement	523	0.52	1.00		

The finding from table 4 demonstrates the link between secondary school students' academic success in biology and their capacity for critical thought. The null hypothesis is disproved since the p-value (0.00) is lower than the alpha (0.05) value. This demonstrates that there is a strong correlation between secondary school students' critical thinking skills and their biology academic success.

Null Hypothesis Two: No significant relationship exists between male secondary school students' critical thinking ability and their academic achievement in biology

Table 5: *T-test for significant relationship between male secondary school students' critical thinking ability and their academic achievement in biology*

Source of Variation	N	Critical thinking ability	Academic Achievement	P-Value	Remark
Critical thinking ability	195	1.00	0.46	0.00	Significant
Academic Achievement	195	0.46	1.00		

Table 5 data demonstrates the link between male secondary school students' academic success in biology and their capacity for critical thought. The null hypothesis is disproved since the p-value (0.00) is lower than the alpha (0.05) value. This demonstrates that there is a strong correlation between the critical thinking skills of male secondary school students and their academic success in biology.

Null Hypothesis Three: No significant relationship exists between female secondary school students' critical thinking ability and their academic achievement in biology

Table 6: *T-test for Significant Relationship between Female Secondary School Students Critical Thinking Ability and their Academic Achievement in Biology*

Source of Variation	N	Critical thinking ability	Academic Achievement	P-Value	Remark
Critical thinking ability	328	1.00	0.55	0.00	Significant
Academic Achievement	328	0.55	1.00		

The correlation between female secondary school students' critical thinking skills and their academic success in biology is displayed in Table 6 of the report. The null hypothesis is disproved since the P-value (0.00) is lower than the alpha (0.05) value. This demonstrates that there is a strong correlation between female students' critical thinking skills and their academic success in biology.

Discussion

A significant favourable association between secondary school students' critical thinking skills and their academic success in biology was found by the study, answering research question one. This conclusion was strengthened by table 4's test of the null hypothesis, which demonstrated a substantial correlation between students' capacity for critical thought and their academic success in biology. The findings of this study lend credence to the findings of Taghva, Razael, Ghaderi and Taghva (2014), Abbasi and Izadpanah (2018), Pozhan, Goordazi and Roozbehani (2019), Shirazi and Heidari (2019), Iqbal, Khan, Javed, Rao and Shams (2021) and Chiketa and Okigbo (2021) who reported in their respective studies in sciences, English studies, Medical sciences, Nursing science, English language and Mathematics that a statistically significant correlation (relationship) exists between students critical thinking ability and their academic achievement.

In terms of gender, the study found that there is a significant positive relationship between women's critical thinking skills and academic success in biology, whereas there is only a slight to moderate positive relationship between male students' critical thinking skills and their achievement in biology. Further analysis of the null hypotheses in tables 5 and 6 demonstrated that there are statistically significant correlations between the critical thinking skills of both male and female students and their academic

accomplishment. The results of this study are consistent with those of Taghva, Rezaei, Ghaderi, and Taghva (2014) and Chiketa and Okigbo (2021), who found that students' critical thinking skills and academic success in the sciences and mathematics, regardless of gender, are significantly correlated. The results of this study concur and disagree with those of Shahzadi, Nimmi, and Khan (2020), who reported that while there is a significant positive relationship between students' critical thinking skills and their academic achievement, it only exists for male students and is not significant for female students.

From the findings above, it can be deduced that critical thinking ability is a necessary tool for enhancing academic achievement of students in biology irrespective of gender, as students tend to understand and achieve better when they are exposed to learning approaches that have them breaking down, analyzing and synthesizing information for themselves, thus fostering their critical thinking ability. Hence, if teachers can employ innovative approaches as well as provide learning situations that can foster and promote students critical thinking ability during the teaching and learning process, this can help enhance their understanding of the concepts in biology and hence achieve better in examinations.

Conclusion

The study concluded that a significant positive correlation (relationship) exists between secondary school students' critical thinking ability and their academic achievement in biology irrespective of gender. That is, as students critical thinking ability is fostered, their academic achievement positively increases.

Recommendations

In the light of the findings of the study, the following recommendations were made:

1. Biology teachers in secondary schools should employ activity-based instructional approaches as well as provide learning opportunities that can foster and promote students critical thinking ability.
2. Seminars, symposia, workshops, and conferences should be organized for biology teachers by the government, education stakeholders and professional bodies (STAN) to educate teachers on the importance of these problem-solving abilities (skills) and how to implement classroom activities that can foster and promote them among students.

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Conflict of Interest

Authors have no conflict of interest.

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ORCID iDs

Izunna Shedrack NWUBA ¹ <https://orcid.org/0000-0002-6408-3912>

Sussan Onyebuchi EGWU ² <https://orcid.org/0000-0002-3048-2165>

Opeyemi Fadekemi AWOSIKA ³ <https://orcid.org/0000-0003-4056-7776>

Abigail Mgboyibo OSUAFOR ⁴ <https://orcid.org/0000-0002-9104-3289>

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