Innovations

Intelligence Quotient as a Predictor of Tertiary Institution Students' Achievement in Chemistry

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Abstract: *The study investigated intelligence quotient as a predictor of tertiary institution students' achievement in in chemistry. Two research questions guided the study and two null hypotheses were tested at 0.05 level of significance. The design adopted for the study was correlation survey. The population of the study was 1, 172 students of chemistry education in public tertiary institutions in Delta state, Nigeria out of 317 students were drawn using purposive sampling technique. Intelligence Quotient Test (IQT) adapted from Carter and Russell (2007) was used for data collection along with the students score sheet. Analysis of data was done by means of simple and multiple linear regressions. The findings of the study revealed among others that 1.2% of the variance in achievement in Chemistry was predicted by students' intelligence quotient. Also, achievement scores in Computer science were significantly predicted by students' intelligence quotient. The most important domains of intelligence for learning chemistry are the spatial intelligence and logical reasoning. It was recommended that orientation and seminars should be designed for chemistry students to help them develop all aspect of their intelligence and to ensure that such abilities are well utilized in the learning of chemistry*

Keyword: 1.*Intelligence, 2.chemistry, 3.achievement, 4. Tertiary 5. regression*

Introduction

Chemistry is essential for meeting our basic needs of food, clothing, shelter, health, energy, and clean air, water, and soil. Chemical technologies as Izuegbunam (2018) puts it, enrich our quality of life in numerous ways by providing new solutions to problems in health, materials, and energy usage. Like all science, the study of chemistry involves specific skills. Students of chemistry according Nwanze and Okoli (2021) learn to pay close attention to detail, solve problems, analyze data, and communicate verbally and in writing. These are skills easily transferred to other fields beyond the realm of science. The importance of chemistry not, withstanding, students' achievement in the subject have not improved as expected even at the tertiary level of education.

Chemistry is first introduced to the students at the secondary level of education. Poor academic foundation in chemistry learning and understanding makes the subject even more difficult when the students get to tertiary institution. Researchers (Pius, 2018; Egbutu & Okoli, 2021; Konyefa & Okigbo, 2021) have continued to believe that the major cause of the poor foundational understanding into the subject of chemistry have remained the poor teaching methods adopted by chemistry teachers. According to Akpokiniovo and Avwiri (2022), little is done at the secondary school level to examine students who make the choice of science-major, choosing chemistry as one of the subject to offer and possibly study at tertiary level of education; to know if their have the intelligence level necessary for science learning. Although, students are streamed into different classes, there are hardly any placement tests or aptitude test like intelligence quotient test, to determine the best possible area of learning that is suitable for the child (Nwanze and Okoli, 2021). This leaves an unanswered fundamental question as to whether

students' streamed into science classes to offer chemistry, do really have the intelligence level for science learning. A much more fundamental question is that of: Does intelligence quotient predict academic achievement in chemistry?

Intelligence quotient (IQ) according to Sania (2019) is a measure of a person's reasoning ability. In other words, an IQ test is supposed to gauge how well someone can use information and logic to answer questions or make predictions. An intelligence quotient is a total score derived from a set of standardised tests or subtests designed to assess human intelligence. A common measure amidst many measure of IQ is that of Carter and Russell (2007). The Carter and Russell (2007) IQ tests are now encountered in recruitment for the government, the armed forces, education, industry and commerce. Their Ultimate IQ Test Book is the biggest book of IQ practice tests available. Written and compiled by IQ-test experts it contains 1000 practice questions organized into 25 tests, with a simple guide to assessing individual performance. The questions themselves are very similar to those faced by candidates in actual IQ tests. They are multi-discipline and include verbal, numerical and diagrammatic reasoning questions, so that readers can practice on all the different types of question they are likely to encounter. Working through the questions can help anyone improve their vocabulary and develop powers of calculation and logical reasoning. By studying the different types of test, and recognizing the different types of question, readers can improve their test scores and increase their IQ rating.

The predictive power of IQ in students' academic achievement at tertiary level in Delta, Nigeria is not in literature. There are barely enough studies probing into how IQ or its domains predict students' academic achievement in chemistry at tertiary level of education. However, literature is replete with a lot of findings indicating IQ is important in science learning. One of the advantages of an IQ test is that it can provide unique and important information about a student's intellectual development that family or professionals may not have picked up on or been able to explain. Again, students who score higher on IQ tests will, on average, go on to do better in conventional measures of success in life: academic achievement, economic success, even greater health, and longevity. Most importantly, many studies found that IQ is a significant factor predicting academic achievement in different subject areas.

Kpolovie (2017) carried out a survey study on intelligence and academic achievement: A longitudinal survey. Kpolovie (2017) found that there was a statistically significant relationship between IQ and Mathematics achievement when English Language is partialled out; and between IQ and English Language achievement when Mathematics is partialled out; respectively across the junior and senior secondary levels of schooling. The results, among others, further indicated overwhelming evidence of stability of intelligence (0.702) with the four-year time interval in super corroboration of fluid and crystalized theory of intelligence. Coefficient of partial determination unveiled that IQ accounted for 24.90% to 24.50% of the variance in Mathematics achievement, and 16.89% to 11.97% of the variance in English Language achievement.

Sania (2019) carried out a study on the comparative analysis of emotional intelligence and intelligence quotient among Saudi business students' academic achievement. The result of the study showed that private students possess a significant IQ, and their academic achievement is primarily driven by IQ and with high EI; whereas public sector students possess moderate EI with insignificant IQ levels and tend to perform average in their academics. All the measurement items of EI and IQ explained only 43.6% of variance in public student's achievement and 56.3% in private student's achievement. The study concluded that the cognitive intelligence is very purposive in academics but narrow in nature and does not extend the horizon of student's lifelong learning and recommended that EI is vital and plays a prominent role in supporting their IQ as well.

Alberto, Alejandro, Zaira and Sandra (2021) conducted a study on intelligence quotient, short-term memory and study habits as academic achievement predictors of elementary school as follow-up study. The result of the study showed that IQ, short-term memory and study habits are significantly related to academic achievement. These variables predicted 56–59 % of the variability of academic achievement. Despite these findings, little is known about how IQ and its domains predict academic achievement in chemistry for tertiary education students especially in Delta state of Nigeria. Thus, there is

the need to further explore the predictive power of intelligence quotient on students' academic achievement in chemistry.

Purpose of the Study

The study specifically, the determined:

- Predictive power of intelligence quotient on tertiary students' achievement scores in chemistry.
- Relative contribution of the domains of intelligence quotient (numerical and verbal aptitude, spatial intelligence and logical reasoning) to tertiary students' achievement in chemistry.

Research Questions

- What is the predictive power of intelligence quotient on tertiary students' achievement scores in chemistry?
- What is the relative contribution of the domains of intelligence quotient (numerical and verbal aptitude, spatial intelligence and logical reasoning) to tertiary students' achievement in chemistry?

Hypotheses

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

- The predictive power of intelligence quotient on tertiary students' achievement in chemistry is not significant.
- The relative contribution of the domains of intelligence quotient (numerical and verbal aptitude, spatial intelligence and logical reasoning) to tertiary students' achievement in chemistry is not significant.

Method

The study adopted correlation survey research design. The area covered in the study was Delta state. The population of the study was 1,172 students of chemistry education in 300 level in public tertiary institutions in Delta state, Nigeria. Purposive sampling technique was used to select 317 from public tertiary institutions in Delta State on the basis that their comprehensive chemistry achievement scores in organic chemistry course was available as at the time of data collection.

The instrument for data collection was Intelligence Quotient Test (IQT) adapted from Carter and Russell (2007) and it had four domains of intelligence: Numeral, aptitude, spatial and logical reasoning. The test was designed to last for 90 minutes. The students' scores in organic chemistry course was obtained and used as their achievement in chemistry. The instrument was administered with the aid of three research assistants who administered the test via a hyperlink for the online test which the students took in real time on their phones.

The scores after the test were collated immediately after the test to ensure that each student's score is recorded against their chemistry achievement score. Simple linear and multiple regressions analysis was used to analyse the data obtained. The interpretation of the correlation coefficient was according Nworgu (2015) who provided a three-way guide for interpreting correlation coefficient values when a large number of pairs of scores have been Correlated.

It followed that R-values$= \pm.30\ and\ below$, indicated low relationship;

$r = \pm.30\ to\ below \pm 0.80$, moderate relationship and $r = \mp.80$ and above, high relationship. The null hypotheses were tested at 0.05 level of significance and the decision rule was to reject the null hypotheses whenever Pvalue is less than or equals 0.05 (P≤0.05) and when otherwise, the null hypotheses was not rejected.

Results

Research Question 1: What is the predictive power of intelligence quotient on tertiary students' achievement scores in chemistry?

Table 1: Predictive Power of Intelligence Quotient on Tertiary Students' Achievement in Chemistry

Model	R	R^2	Adjusted R^2	Unstandardized coefficients (b)	Std. Error	Decision
Constant Int. Quotient	.111 [a]	.012	.009	64.878 .109	12.567	Low positive relationship

a. Predictors: (Constant), Intelligence Quotient

Table 1 shows a low positive relationship (R = 0.111) exists between tertiary students' intelligence quotient and their achievement scores in chemistry. The R-Square value indicates that 1.2% of the variance in their chemistry scores is predicted by intelligence quotient.

Research Question 2: What is the relative contribution of the domains of intelligence quotient (numerical and verbal aptitude, spatial intelligence and logical reasoning) to tertiary students' achievement in chemistry?

Table 2: Contributions of the Domains of Intelligence Quotient in Tertiary Students' Score in Chemistry

Model	Unstandardized Coefficients		Standardized Coefficients	R	R squared	t	Sig.
	B	Std. Error	Beta				
(Constant)	63.540	3.201				19.848	.000
Numerical	.158	.114	.079			1.383	.168
1 Aptitude	.287	.153	.104	.205[a]	.042	1.874	.062
Spatial	.264	.118	.129			2.229	.027
Logical reasoning	.189	.112	.095			1.688	.029

a. Dependent Variable: Chemistry Academic Achievement

Table 2 shows a low positive relationship (R = 0.205) exists among all the domains intelligence quotient and achievement in chemistry. The R-Square value of 0.042 indicates that 42% of the variance in chemistry scores is jointly predicted by the domains of intelligence quotient. Table 2 also shows the standardized beta coefficient which indicates correlation between variables. The unstandardized beta coefficient shows the prediction powers of each dimension of intelligence quotient which indicates their relative contribution to achievement in chemistry. It shows that numerical dimension has a low positive predictive relationship (R = 0.079) with students' achievement in chemistry, aptitude has a low positive relationship (R = 0.104) with achievement in chemistry, while spatial dimension has a low positive relationship (R = 0.129) with achievement, and logical reasoning has a low positive relationship (R = 0.095) with achievement in chemistry. Table 2 further reveals that numerical dimension of intelligence quotient contributes 0.158 to achievement in chemistry whenever a students' numerical domain of intelligence quotient increase by one unit. A unit increase in aptitude increases achievement by 0.287, a unit increase in spatial domain increases achievement by 0.264, where a unit increase in logical reasoning increases achievement by 0.189. The order of relative contribution to achievement in chemistry from the highest to lowest by each domain of intelligence quotient is; aptitude (0.287), followed by spatial (0.264), logical reasoning (0.189), and then numerical domain (0.158).

Hypothesis 1: The predictive power of intelligence quotient on tertiary students' achievement in chemistry is not significant.

Table 3: ANOVA on Significance of Prediction of Achievement in Chemistry by Students' Intelligence Quotient

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression 1	624.298	1 315	624.298	3.953	.048[b]
Residual	49749.500		157.935		
Total	50373.798	316			

a. Dependent Variable: Chemistry Achievement

b. Predictors: (Constant), Intelligence Quotient

Table 3 reveals that intelligence quotient is a significant predictor of achievement scores in chemistry F (1, 315) = 3.953, P (0.048) < 0.05. The null hypothesis was therefore rejected meaning that intelligence quotient is a significant predictor of tertiary students' achievement scores in Chemistry.

Since intelligence quotient is a significant predictor of achievement scores in chemistry, the regression model (Y= C + aX) for the prediction of achievement score in chemistry as derived from Table 1, where constant = 64.878 and b value = 0.109 is:

TSAC = 64.878 + 0.109(IQ)

Where, TSAC = Tertiary Students' Achievement in Chemistry and IQ = Intelligence Quotient **Hypothesis 2:** The relative contribution of the domains of intelligence quotient (numerical and verbal aptitude, spatial intelligence and logical reasoning) to tertiary students' achievement in chemistry is not significant.

Table 4: ANOVA on Significance of Prediction of Achievement in Chemistry by the Individual Domains of Intelligence Quotient

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression 1	2108.396	4 312	527.099	3.407	.010[b]
Residual	48265.402		154.697		
Total	50373.798	316			

a. Dependent Variable: Chemistry Achievement

b. Predictors: (Constant), Logical reasoning, Aptitude, Numerical, Spatial

Table 4 shows that the co-predictive power of the domains of intelligence quotient on tertiary students' achievement scores in chemistry is significant F (4, 312) = 3.407, P (0.010) < 0.000. However, data contained in Table 3 shows the significance of the contributions of the individual domains to the prediction of achievement scores in chemistry.

Table 3 shows that numerical dimension is not a significant predictor of achievement scores in chemistry, t = 1.383, P (0.168) < 0.05, aptitude is not a significant predictor of achievement scores in chemistry, t = 1.874, P (0.062) < 0.05, spatial dimension is a significant predictor of achievement scores in chemistry, t = 2.229, P (0.027) and logical reasoning is also a significant predictor of achievement scores in chemistry, t = 1.688, P (0.029) < 0.05. Thus, only the spatial and logical reasoning domains of intelligence quotient are significant contributors to the achievement of tertiary students in chemistry. However, the regression model ($Y= C + aX_i + bX_{ii} + cX_{iii} + dX_{iv}$) for the prediction of achievement score in chemistry as can be derived from Table 2, where constant = 63.540 and a value = 0.158, b value = 0.287, c value = 0.264 and d value = 0.189 is:

TSAC = 63.540 + 0.158(NI) + 0.287(A) + 0.264(SI) + 0.189(LR)

Where, TSAC = Tertiary Students' Achievement in Chemistry and NI = numerical intelligence, A = Aptitude, SI = Spatial Intelligence, LR = logical reasoning

Discussion

The findings of the study showed that intelligence quotient significantly predicted 1.2% of tertiary students' achievement in chemistry and contributes a 0.109 increase in academic achievement in

chemistry with its unit increase. The study's observed results can be attributed to the idea that high intelligence is a reliable indicator of positive outcomes, including academic achievement. High IQ students are more likely to participate in programmes that prepare them for school, get good grades, spend more time on their homework, miss fewer classes, feel more comfortable studying chemistry, and have better self-esteem. Again, intellectual quotient plays a significant role in how well students learn chemistry by influencing their mental agility, capacity for pattern recognition and application, and ability to manage mental complexity. Students with high IQs may be able to manage attention deficit disorders like inattention, simple distractibility, disorganisation, procrastination, and forgetfulness. As a result, these students are able to multitask while ensuring attentional selection between two sets of information related to separate tasks, detach attention from unimportant items while attending to new relevant and items, and shield themselves from conflicting information when learning.

The study also revealed that the most important domains of intelligence quotient for learning chemistry are spatial and logical reasoning. Students can comprehend the position, size, and relationships between various things by using spatial thinking. Additionally, it enables mental manipulation of items and shapes. Understanding how people and objects move through their surroundings can help students to better comprehend stereochemistry. Navigation and the creation of episodic memories both depend on spatial learning and recall. Equations and other written, modelled, diagrammatic instruction, such as visual representations of reactions and other chemistry ideas, are effective teaching tools for students with strong spatial memory. Students are extremely capable of solving chemistry related problems when logical reasoning is combined with them. Unquestionably, scientific or logical reasoning is a crucial skill in studies involving science because it guarantees successful experimentation, hypothesis testing, data analysis, and conclusion-drawing. First, logic gives students the power and capability to build on the knowledge they are given. It is also the foundation of arithmetic. Logical reasoning encourages students to engage in independent thought, experimentation, and even in big, unconventional issues.

The findings of the study are related to the findings of Alberto, Alejandro, Zaira and Sandra (2021) that IQ is significantly related to academic achievement. The findings of the study are in line with the findings of Sania (2019) that students' academic achievement is primarily driven by IQ. The findings of the study does not contradict the findings of Kpolovie (2017) that a statistically significant relationship exist between IQ and achievement

Conclusion

The conclusion that can be drawn from the study is that tertiary students' intelligence quotient is a significant factor that affects their learning of chemistry and the possible academic achievement attainable by their in organic chemistry. The study also establishes that spatial intelligence and logical reasoning are very important domains of intelligence needed for the study of organic chemistry where stereochemistry is an important aspect.

Recommendations

In the light of the findings of the study, it is therefore recommended that:

- Chemistry related test items should be designed and constructed to develop different aspects of tertiary students' intelligence quotient. This effort by chemistry teachers and test and measurement experts should be commenced from the onset of the introduction of chemistry to students at the secondary school level.
- Orientation and seminars should be designed for chemistry students to help them develop all aspect of their intelligence and to ensure that such abilities are well utilized in the learning of chemistry.

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