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Examining the role of intelligence quotient in predicting senior secondary school students' achievement in chemistry

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ABSTRACT

The study examines the role of intelligence quotient (IQ) in predicting academic achievement in chemistry among senior secondary school students. The purpose of the study is to determine i) whether IQ predict chemistry achievement scores of senior secondary school students in chemistry and ii) the proportion of senior secondary school students' chemistry achievement is attributable to the IQ areas of logical thinking, spatial intelligence, numerical, and verbal aptitude. The study's research design was a correlation. The study was guided by two research questions and two null hypotheses. The study included 1,022 senior secondary school chemistry students as its population. A sample of 320 senior secondary school chemistry students was chosen using random sampling methods from 10 public schools. Three experts validated the intelligence quotient test (IQT), which was used as the data gathering tool. IQT's dependability was determined to be 0.68 utilizing Kuder-Richardson formula 20 (KR-20). Both simple and multiple linear regressions were used to examine the collected data. Among other things, the study's results showed that students' IQ predicted 1.3% of the variation in their chemistry achievement. The results showed that the four components of IQ—numerical, aptitude, spatial, and logical—all significantly influence students' achievement in chemistry. Additionally, students' IQ substantially influenced their chemistry achievement ratings. Since chemistry achievement is heavily influenced by numerical, aptitude, spatial, and logical intelligence, students might benefit from specialized teaching strategies that support these domains. The addition of IQ test results as a requirement for enrollment in chemistry courses was suggested.

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1. INTRODUCTION

The science of chemistry examines the characteristics of matter and the materials that surround us. It examines materials, their constituents, characteristics, and reactions; it also discusses the use of the byproducts (new chemicals) of these processes. The primary goal of science education is to help students become scientifically literate [1]. This entails scientists and students studying chemistry actively participating in the practices, mastering reaction processes, and managing the knowledge of chemistry to meet individual and social needs. Akudo [1] noted that science and technology are so indispensable that any society or nation without them runs the risk of becoming estranged from the rest of the world due to the rapidly evolving

applications of these fields and the worldwide dependence on their products and outputs in all spheres of human endeavor. This implies that a person has to have completed a well-designed, evaluated, and executed scientific program in order to be well-versed in science, of which chemistry is one, and capable of handling the difficulties of daily living in his or her community.

Chemistry has a lot to do with the advancement of the country. Akudo [1] pointed out that chemistry plays a crucial role in a country's development, particularly in Nigeria, where the petroleum and petrochemical sectors provide the majority of the country's income. A key component of the push for sustainable economic growth on a worldwide scale is chemistry. Fertilizers and insecticides, clothing (textile fibers), housing (cement, concrete, steel, and bricks), medicine (drugs), transportation (fuel and alloy materials), and many other products like paints, soaps, cosmetics, and more all depend on it. Furthermore, there are numerous career options in chemistry in the extractive, food processing, health, petroleum, and petrochemical sectors. Chemistry instruction serves to instill scientific knowledge and encourage science-oriented attitudes in students by serving as a precondition for further study of science and science-related fields. When these attitudes are applied to the workplace, they improve society, the individual, and the citizens' overall quality of life. Nwanze and Okoli [2] stated that chemistry students acquire the ability to solve issues, pay great attention to detail, evaluates data, and communicate both orally and in writing. These are abilities that can be readily used outside of the scientific domain.

According to previous studies [3], [4], academic achievement is the grade a student receives in a variety of academic subjects. Standardized test scores, graduation rates, and classroom evaluations are commonly used by educators to gauge student achievement [4]. According to Akinleke [5], a student's academic achievement is determined by how well they do on tests, exams, and coursework. Academic achievement, as defined by Maureen and Chinelo [4], is the knowledge acquired that is evaluated by a teacher using grades and/or educational objectives that students and instructors establish to be met over a certain amount of time. The authors went on to say that the outcomes of ongoing assessments or exams are used to gauge these objectives. The academic achievement of senior secondary school students studying chemistry is defined as their ability to grasp the subject matter. Numbers that represent academic achievement are developed to show how well students do after completing classroom teaching [6]. Test results in the form of scores may be used to gauge how well students have the subject and to assess how well the teaching and learning process is going over a specific time frame.

The first-time chemistry mastered is taught to students is in senior secondary school. Students who have a weak academic background in chemistry find the subject considerably more challenging when they enter postsecondary education. According to several researchers [7]–[9], students' inadequate basic knowledge of chemistry is still mostly caused by the subpar teaching strategies used by chemistry instructors. Students who choose to major in science and choose chemistry as one of the subjects to offer and potentially study at the tertiary level of education are rarely examined at the secondary school level to see whether they possess the intellect level required for science learning.

It is necessary for students to be able to actively and independently expand their knowledge and intelligence. According to Marwaha *et al.* [6], students must possess critical thinking abilities that enable them to make trustworthy judgments and pick up new information fast. It indicates that one is capable of understanding oneself and making an attempt to develop a solid self-image, support students' positive behavior, and stop bad behavior. There are times when students struggle to favorably shape their attitudes, ideas, and selves. Since intelligence is an abstract term, most people think of it as the capacity to comprehend and absorb new ideas easily. The ability to gain information and comprehension and use it in many unique contexts is the restricted definition of intelligence [4], [10], [11]. According to several studies [6], [11]–[15], intelligence is a key component that may forecast academic achievement in schools and plays a significant part in kids' future success.

Every person in every field has been impacted by the concept of intelligence [13]. It is in charge of both academic achievement and, eventually, life success. It enables us to succeed and overcome obstacles in life. If a youngster is raised in a loving atmosphere, they can fully develop their intellectual potential [13], [16]. According to study by Marwaha *et al.* [6], intelligence affects students' capacity to assimilate new information or knowledge and use it as the foundation for processing and problem-solving. Pokhriyal and Pangtey [17] defines it as a person's capability to deal with real-world events and derive intellectual benefits from sensory experience. The word "intelligence quotient" is frequently used to describe the qualities of thinking that include reasoning, planning, problem solving, abstract cognition, concept understanding, language usage, and learning [18]. Intelligence quotient (IQ), then, is the capacity of an individual to respond appropriately to a stimulus that they have received. An intelligence quotient test (IQT) is a psychometric instrument used to assess intellect. The word IQ refers to a broad range of mental skills, including reasoning, planning, problem-solving, abstract thought, concept understanding, language usage, and learning [14], [19]. The purpose of the IQT is to formally examine, under test settings, a person's ability

to adjust to a certain circumstance. Thinking, remembering, reading, learning, problem solving, and language use are all cognitive abilities that are strongly correlated with intelligence [6]. Tests of IQ are psychometric instruments used to evaluate intellect. An ability that encompasses a variety of skills, including reasoning, planning, problem solving, abstract thinking, concept understanding, language usage, and learning, is sometimes referred to as IQ.

The generic name for mental qualities that include reasoning, planning, problem-solving, abstract thought, language use, concept understanding, and learning is IQ [19]. According to previous studies [14], [20], IQ is the capacity of an individual to respond appropriately to a stimulus that is presented to them. According to Marwaha *et al.* [6], those with low IQs were more likely to be impulsive, hostile, and disappointed during the educational process. The results of an IQ test are a reliable indicator of a student's academic performance in school, income, work performance, and any other factors influencing success in life [6]. Good IQ scores are also associated with good academic accomplishment, and vice versa [6], [14], [21], [22]. High IQ students are probably going to do better academically than low IQ students [21].

The study of Kullar *et al.* [22] showed that, in comparison to students with normal IQs, those with low IQs achieve noticeably less academically. This demonstrates how pupils' academic performance is influenced by their IQ levels. According to a prior study by Guez *et al.* [21], pupils with low IQs have low learning achievements in mathematics, while those with high IQs have excellent learning achievements. According to a study of Hendriyanto and Juandi [14] on the relationship between mathematics achievement and IQ that examined basic relations in high school students in class 10, students' IQ level had an impact on their math achievement. Intelligence test scores are correlated with academic achievement, as numerous studies have demonstrated [12]. Adeyemi and Fatoye study [23] on IQ as a predictor of lower primary school students' success in social studies, showed that there is a relationship between IQ and student's achievement.

Predicting academic success has emerged as a significant issue in contemporary research. Many studies [6], [18], [24], [25] on the prediction of achievement by IQ as a predictor of achievement have been conducted. All of these studies have concluded that high intelligence does not equate to knowledge or that intelligence influences achievement. However, the issue of how to measure genuine intellect and use test results to gauge intelligence level has plagued academics from the first to the most current studies. Standardized intelligence test results, or IQ scores, are frequently used to determine an individual's degree of intellect. However, it is widely accepted that they just give a glimpse of a person's aptitude in the field being studied and do not present the full picture. For instance, someone with a high verbal IQ can only be considered to have a high IQ in verbal, and someone with a high mathematics IQ can only be considered to have a high IQ in mathematics. It goes without saying that the more diverse the disciplines that are tested and analyzed, the more precisely the person's IQ may be determined.

Kpolovie [26] asserts that several standardized IQ tests have been created and given by qualified psychologists. According to Kpolovie [26], the absence of a single standardized test that can assess intelligence comprehensively has led to a significant gap in research on intelligence. These disparities arise because several components of intelligence, including general intelligence, verbal/linguistic intelligence, logical intelligence, visual/spatial intelligence, and intrapersonal intelligence, are measured by different tests. It is challenging to determine which aspects of intelligence is a good predictor of success in subject like chemistry since tests assessing several aspects of intelligence are used. Thus, the purpose of the study is to determine: i) whether IQ predict chemistry Achievement scores of senior secondary school students in chemistry in Delta Central Senatorial District, Delta State, Nigeria and ii) the proportion of senior secondary school students' chemistry achievement is attributable to the IQ areas of logical thinking, spatial intelligence, numerical and verbal aptitude. In addition, the research questions for this study are:

i) How well does IQ predict chemistry Achievement scores of senior secondary school students in chemistry?
ii) What proportion of senior secondary school students' chemistry achievement is attributable to the IQ areas of logical thinking, spatial intelligence, numerical and verbal aptitude?

Furthermore, the following hypotheses were stated to guide the study: i) the chemistry achievement scores of secondary school students do not significantly correlate with the prediction potential of IQ (H1) and ii) the IQ areas of spatial intelligence, logical thinking, numerical and verbal ability do not significantly contribute to the chemistry achievement of senior secondary school students (H2).

Many studies have been carried out to determine the relationship between the students' IQ and their academic achievement, but to my best of knowledge no research has been carried out on senior secondary students IQ and their chemistry achievement in Delta Central Senatorial District, Delta state, Nigeria hence this study was carried out. The objectives of this study is to find out whether IQ really correlates with students achievement in chemistry and also to determine whether the numerical, aptitude, spatial and logical reasoning dimension of IQ correlates with senior secondary students' achievement in chemistry.

2. METHOD

The study's research design was correlational. According to Nworgu [27], a correlation design is a study that establishes the link among two or more variables of interest to the researcher. Nworgu [27] claims that correlation studies show the strength and direction of the association between the variables. The design was chosen because the goal of the current study was to determine the predictive link between the academic achievement of chemistry students in Delta Central Senatorial District, Delta State, Nigeria, and their IQ. The study population included 1,022 senior secondary school students offering chemistry in public school. There were 320 senior secondary school students made up the study's sample, which was selected from 10 public secondary schools in the Delta Central Senatorial District using random sampling. According to the Research Advisors [28], a sample size of 291 from a population of 1,200 students with a confidence level of 95%, and a margin of error of 5% is quite appropriate, based on this the sample size was chosen. The IQT, which was modified from Carter and Russell [29], was the tool used to gather the data. In particular, the four aspects of intelligence—numerical, aptitude, spatial, and logical reasoning—are covered in the 40-item IQT exam. The test had 60-minute duration. The students' chemistry achievements were determined by taking their organic chemistry course scores. The instruments were evaluated by three specialists. The selection of these three experts was based on their professional expertise linked to the construct being assessed, their specific understanding of the instrument, and their familiarity with psychometric qualities such as validity (content, construct, and criteria). To determine the IQT's dependability, Kuder Richardson Formula 20 (KR-20) was used and the reliability coefficient of 0.68 was obtained. These values are good enough for the instruments to be reliable according to Zahfa *et al.* [30], since it is above average of 0.50. Multiple and simple linear regressions were used to examine the relationship between the independent variable (predictor) and the dependent variable (achievement).

3. RESULTS AND DISCUSSION

3.1. Results

3.1.1. How well does IQ predict chemistry achievement scores of senior secondary school students in chemistry?

According to Table 1, there is a low positive correlation (R=0.115) between the IQ of senior secondary school students and their chemistry achievement scores. According to the R-square value, their IQ predicts 1.3% of the variation in their chemistry scores. Table 1 indicates that there is a correlation between senior secondary school students in Delta Central Senatorial District, Delta state, Nigeria public secondary school and their academic achievement in chemistry although low positive relationship.

Table 1. IQ predictive power on chemistry achievement in senior secondary school students

Model	R	R^2	Adjusted R^2	Unstandardized coefficients (b)	Std. Error	Decision
Constant	0.115[a]	0.013	0.011	63.975	13.053	Low positive relationship
IQ				0.114		

a. Predictors: (constant), IQ

3.1.2. What proportion of senior secondary school students' chemistry achievement is attributable to the IQ areas of logical thinking, spatial intelligence, numerical and verbal aptitude?

The standardized beta coefficient, which indicates correlation between variables, and the unstandardized beta coefficient, which shows the prediction powers of each dimension of IQ, which indicates their relative contribution to achievement in chemistry, are both displayed in Table 2, which also reveals a low positive relationship (R=0.208) between all the domains of IQ and achievement in chemistry. The R-square value of 0.043 indicates that the domains of IQ jointly predict 4.3% of the variance in chemistry scores. It demonstrates that students' chemistry achievement is weakly positively predicted by numerical dimension (R=0.086), weakly positively predicted by aptitude (R=0.109), weakly positively predicted by spatial dimension (R=0.132), and weakly positively predicted by logical reasoning (R=0.089). Furthermore, Table 2 shows that for every unit rise in a student's numerical domain of IQ, the numerical dimension of IQ adds 0.152 to achievement in chemistry. Achievement increases by 0.298 for every unit increase in aptitude, 0.274 for each unit increase in spatial domain, and 0.169 for each unit increase in logical reasoning. Aptitude (0.298) is the domain with the biggest relative contribution to chemistry achievement, followed by spatial (0.274), logical thinking (0.169), and numerical domain (0.152), in that order.

Table 2. The domains of IQ contributions to secondary students' chemistry scores

Model		Unstandardized coefficients B	Unstandardized coefficients Std. Error	Standardized coefficients Beta	R	R^2	T	Sig.
1	(Constant)	61.540	2.965		0.208[a]	0.043	20.848	0.000
	Numerical	0.152	0.079	0.086			1.810	0.028
	Aptitude	0.298	0.137	0.109			2.374	0.018
	Spatial	0.274	0.087	0.132			3.109	0.009
	Logical reasoning	0.169	0.081	0.089			2.121	0.031

a. Dependent variable: chemistry academic achievement

3.1.3. The chemistry achievement scores of secondary school students do not significantly correlate with the prediction potential of IQ (H1)

According to Table 3, IQ significantly predicts chemistry achievement scores F(1, 318)=4.745, P(0.021)<0.05. As a result, the null hypothesis which states that the chemistry achievement scores of secondary school students do not significantly correlate with the prediction potential of IQ was disproved. It indicating that IQ significantly predicts senior secondary school students' chemistry achievement scores.

Table 3. ANOVA[a] on the relevance of chemistry achievement prediction based on students' IQ

	Model	Sum of squares	Df	Mean square	F	Sig.
1	Regression	624.323	1	624.323	4.745	0.021[b]
	Residual	39367.224	318	137.019		
	Total	39991.547	319			

a. Dependent variable: chemistry achievement
b. Predictors: (constant), IQ

3.1.4. The IQ areas of spatial intelligence, logical thinking, numerical and verbal ability do not significantly contribute to the chemistry achievement of senior secondary school students (H2)

Table 4 demonstrates that the achievement scores of senior secondary students in chemistry were jointly predicted by all individual dimensions of IQ: F(4, 314)=4.002, P(0.013)<0.05. However, the information in Table 4 demonstrates the importance of each dimension's contributions to the prediction of chemistry achievement scores. Table 2 demonstrates that numerical dimension is a significant predictor of chemistry achievement scores (t=1.810, P(0.028)<0.05), aptitude is a significant predictor of chemistry achievement scores (t=2.374, P(0.018)<0.05), spatial dimension is a significant predictor of chemistry achievement scores (t=3.109, P(0.009)<0.05), and logical reasoning is also a significant predictor of chemistry achievement scores (t=2.121, P(0.031)<0.05). The achievement of students in chemistry is therefore significantly influenced by all aspects of IQ. Since the prediction of chemistry achievement score is significantly influenced by the combined prediction of all IQ components.

Table 4. ANOVA on the relevance of predicting chemistry achievement by the different IQ domains

	Model	Sum of squares	Df	Mean square	F	Sig.
1	Regression	3102.372	4	439.437	4.002	0.013[b]
	Residual	55375.620	314	142.334		
	Total	58477.992	315			

b. Predictors (constant), logical reasoning, aptitude, numerical, spatial

3.2. Discussion

According to the study's findings, there is a weak positive correlation between students' IQ and their achievement in chemistry, with IQ substantially predicting 1.3% of the variation in chemistry scores. The study's results are consistent with those of Maureen and Chinelo [4] and Marwaha *et al.* [6], who found a substantial relationship between students' academic achievement in biology and their IQ. The study's results are consistent with that of Kpolovie [26], who found a statistically significant correlation between IQ and mathematical proficiency. The current study supports Kpolovie [26] results that private student have a high IQ and that IQ is the main factor influencing their academic success. The study's results supported those of Akubuilo *et al.* [24], who found that IQ was a strong predictor of performance. The research results also support those of Quilez-Robres *et al.* [31], who found a substantial relationship between academic accomplishment and IQ, short-term memory, and study habits.

The study's findings support those of Marwaha *et al.* [6] by demonstrating a link between IQ and chemistry. The findings of Kullar *et al.* [22] shown that, in comparison to pupils with normal IQs, those with

low IQs achieve noticeably less in the classroom which support the present study. This indicates that the academic achievement of senior secondary school students in chemistry is influenced by their IQ levels. Study by Hendriyanto and Juandi [14] found that students' IQ level had an impact on their mathematical achievement. According to a prior study by Guez *et al.* [21], pupils with high IQs accomplish well academically, whereas those with low IQs perform poorly in mathematics, which are consistent with the present study. This implies that students' IQ level has an impact on their academic success. Higher IQ scores are often associated with greater academic accomplishment; academic achievement is significantly influenced by one's self-perception and confidence in one's skills, even though IQ is crucial [32]. This study highlights how motivation and consistent attendance may either strengthen or lessen the impact of IQ on academic accomplishment, even when IQ is a valid predictor [6], [33].

The study findings agree with research by Marwaha *et al.* [6] who investigated the connection between students' IQ and their academic performance in biology, which can offer information pertinent to other courses, such as chemistry. Higher IQ scores are associated with better academic results, according to their research, which showed a substantial positive association (R=0.760) between IQ and biology achievement. This association suggests that chemistry achievement may follow comparable trends. The relationship between a student's IQ and academic success in school varies according to the lessons and the student's developmental stage. Higher IQ students have a greater chance of learning success and get better academic results because they are comparatively easier to grasp the course material and more engaged in the learning process [17]. Under identical circumstances, students with higher IQs have greater achievement than those with lower IQs. Based on this assertion, it may be said that students with higher IQs can benefit from better learning environments and achieve more success.

The discovery is explained by the fact that IQ has a significant role in comprehending abilities and overall achievement. On average, students with higher IQ scores will perform better on conventional measures of life success, such academic achievement. More education is completed by students who are more likely to be intelligent, or intellect rises with longer schooling. Compared to kids with low IQs, those who are able to comprehend and retain their coursework do better on tests. Due to their weak learning abilities, low IQ students require longer time to understand concepts, which inevitably results in low academic achievement. This is better demonstrated by the part that the various IQ components play in learning science courses like chemistry. Numerical intelligence and academic calculations and problem solving are strongly related. Aptitude is the ability to succeed in a certain profession, like chemistry. It might be innate, natural, taught, or acquired, or it can be a special ability or set of abilities that could help someone carry out specific tasks effectively. For this reason, it is crucial for chemistry calculations and practical applications. A learner may make an educated choice if they are aware of these strengths. A student's performance in that particular material can be improved by using aptitude to determine their occupational strengths and weaknesses in particular areas of chemistry.

Additionally, testing may be used to determine a person's IQ, which can help them learn more efficiently and accomplish their objectives. Students that use spatial thinking are able to comprehend the dimensions and locations of items as well as the relationships between them. Additionally, it enables you to control and see shapes and things in their mind. Students who understand object categories and qualities are able to arrange objects in their environment both physically and psychologically. Students that possess spatial awareness and spatial connections are able to identify items and traverse chemistry with ease. As a result, students' spatial intelligence is maximized in animations and images. Students apply their reasoning skills in a variety of contexts, including schooling and life in general.

4. CONCLUSION

The study comes to the conclusion that students' achievement in the science of chemistry is significantly predicted by their IQ. It is clear that there is a significant relationship between the chemistry proficiency of senior secondary school students in Delta Central Senatorial District and the IQ variable. According to the study, every aspect of IQ that was looked at had a major impact on students' achievement in chemistry. The findings of the study lead to the following recommendations; The design and construction of chemistry-related exam items should focus on developing several facets of secondary school students' IQ. Students should be required to take IQT on a regular basis so that teachers and the school can assess their overall performance and ability.

Practical implications for the study: to improve students' comprehension and performance in chemistry, teachers should use a variety of teaching techniques rather than depending just on IQ. Differentiated education strategies that address each student's cognitive strengths and limitations can be developed by schools. The authors suggest that more study be done on the relationship between IQ and junior secondary school students' chemistry achievement. The same area or location used in this study may be used

for further research on the IQ as a predictor of tertiary students' success in chemistry. Using different disciplines, research on IQ as a predictor of tertiary students' success may be conducted. Additionally, the predictive function of the IQ should be tested with different subject areas

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Onoshakpokaiye Ejakpomeghwe Odiri	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

There is no conflict of interest.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author [OEO], upon reasonable request.

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