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Differential Aptitude As Predictor Of Secondary School Students' Academic Achievement In Biology In Onitsha Education Zone

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Abstract: ***The study investigated differential aptitude as predictors of secondary school students' academic achievement in biology. Two research questions and two null hypotheses guided the study. Correlation design was adopted for the study. The population of the study was 2,461 senior secondary year two (SS2) students offering Biology in Onitsha Education Zone in 2022/2023 out of which a sample of 736 students were drawn for the study. The instrument for data collection was Differential Aptitude Test (DAT) validated by three experts. The reliability of the instrument DAT was established using Kuder-Richardson Formula 20 (KR-20) to be 0.80. 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 1.1% of the variance in achievement in biology was predicted by students' differential aptitude. Also, achievement scores in Biology were significantly predicted by students' differential aptitude. It was recommended that teachers of biology at secondary schools should give students assignments that border on verbal and perceptual aptitudes to help them exercise these abilities and be cognitive engaged in order to improve biology achievement.***

Keyword: differential-aptitude, achievement, biology predictor

I. INTRODUCTION

Biology is the scientific study of life. It is defined by Ezenwabachili and Okoli (2021) as a natural science with a broad scope and has several unifying themes that tie it together as a single, coherent field. Biology has gained popularity as it continues to remain the popular subject offered by both science and non-science students. The popularity of the subject is closely related to its importance. This is because, as a field of science, Biology helps us understand the living world and the ways its many species (including humans) function, evolve, and interact. Advances in medicine, agriculture, biotechnology, and many other areas of Biology have also brought improvements in the quality of life. Thus, the knowledge of Biology allows students to better understand their bodies, their resources, environment and the potential threats to them.

Despite the importance and popularity of Biology, students' achievement in the subject has not improved as expected, as the percentage number of students who obtain a credit pass and above in the subject has improved as expected. The West African Examination Council (WAEC) Chief Examiner's Report from 2012-2019 shows that apart from 2012 where 35.66% of the students passed at credit level and above, students who passed at credit level and above from 2013-15 remained below 57%. From 2016-2018, the percentage number of students who passed at credit level and above decreased from 61.68-55.10. The decreased in percentage number of students who passed at credit level and above continued to 2019 where although 55.63 passed, it represented 482,033 students as compared to 488,460 students in 2018. The insignificant improvement and continual rise and fall in the percentage of students passing the subject at credit level and above instigate a need to seek ways to improve students' achievement in biology.

Achievement is the out of education, the extent to which the objectives of instruction has been met. Academic achievement is the grade of a student in an achievement test

given using standard test and examinations. Thus, academic achievement can be measured or obtained via standard test and test in psychomotor and affective domains. A lot of factors have been advanced for the poor achievement of students in Biology. Several researchers have shown that some of the factors include; inadequate motivation from teacher, poor incentives to Biology teachers (Ezenwabachili and Okoli, 2021), use of teacher centered instructional materials, lack of qualified teachers, large content scope of Biology curriculum, lack of adequate supply of instructional materials (Avwiri and Okoli, 2021), poor laboratory practical activities, over-crowded Biology classroom (Egbutu and Okoli, 2021), teaching methods adopted by Biology teachers and poor attitude of students towards the subject (Udegbe and Okoli, 2022). These studies among others have been investigating these factors implicated to see how to improve students' achievement, but despite the research efforts and several reports from WAEC Chief examiner's, students' achievement have not improved significantly.

The fundamental question becomes: What factors relating to the students themselves predict their achievement in Biology? Some of the factors according to Anazia (2019), Eric, Peter, Aloka and Benson (2018), Farida (2020), that have been shown to predict achievement but which have not been widely explored research wise, especially in Nigerian secondary school education system are differential aptitude, cognitive engagement, cognitive style and intelligence quotient. The present study took interest in differential aptitude as it has not been widely researched as variables having significant predictive power and determinants of students' achievement in biology.

The concept of aptitude has been variously defined by authors. An aptitude is a condition or set of characteristics regarded as symptomatic of an individual's ability to acquire with training some knowledge and skill (Anazia, 2019). According to Curabay (2016), it is a present condition which is indicative of an individual's potentialities for the future. Aptitude has been defined by Farida (2020) as a measure of the probability of the success of an individual, with training in a certain type of situation such as a job in school or in such activities as playing the violin or learning a language. An aptitude is a unique combination of abilities and personality characteristics which predisposes a person to do one kind of work better than another and increases his chances of success at it. In this study, aptitude is taken to be a component of a competence to do a certain kind of work at a certain level. It is the present ability of an individual to perform a special work successfully. Thus, outstanding aptitude can be considered "talent." Thus, differential aptitude has been consistently used to mean ability of an individual to perform a special work successfully and how much such ability is a mark of difference that distinguishes a student from another. Aptitude test or tests of such special ability predicts about an individual whether he will be successful in a particular area or field if trained. An example of such test is the Differential Aptitude Test (DAT).

Differential Aptitude Test (DAT) is an integrated battery of psychometric tests designed for educational and vocational guidance of school children (Mankar and Chavan, 2013). The tests measure the following eight aptitudes: language aptitude, abstract reasoning, verbal reasoning, mechanical reasoning, numerical aptitude, spatial aptitude and perceptual aptitude. DAT evaluates the ability to acquire a set of cognitive skills such as reasoning (verbal, abstract, and mechanical), spelling, numerical ability, perceptual accuracy and speed, and space relations.

The results of from DAT help identify strengths and weaknesses, educational options, and career paths. Thus, DAT pinpoints mental strengths and weaknesses and predicts success both in school and in the workplace. The DAT used in the present study measured and determine the students' differential aptitude in eight areas; language aptitude, abstract reasoning, verbal reasoning, mechanical reasoning, numerical aptitude, spatial aptitude and perceptual aptitude. Language aptitude according to Wyk (2012) is concerned with a person's ability to use and understand written language. The sub-test assesses how well a student understands English words and their synonyms, spell words correctly and identify correct meaning of any given proverbs/idioms. Abstract reasoning refers to a person's ability for logical and analytical thinking (Mawak and Wakdos, 2017). The sub-set is non-verbal and it assesses how well a student can reason and logically relate geometric shapes or designs. In the sub-set, set of figures are given in a certain sequence and students are required to infer the next figure. Verbal reasoning according to Corengia, Pita, Mesurado and Centeno (2013) is the ability to understand and reason using concepts expressed in words. It evaluates a students' ability to think constructively with words. In the sub-set, verbal reasoning is assessed by the ability to understand concepts and relationships that are underlying a word pair and then find the missing word in a pair with similar concepts and relationships.

Mechanical reasoning refers to a person's ability to understand and apply mechanical concepts and principles to solve problem (Ayeni and Olasunkanmi, 2015). In the sub-set, mechanical reasoning is assessed by items covering the areas of acceleration, pressure, energy transformation, work and power, levers, pulley, screws and springs and tools among others. Numerical aptitude refers to understanding numerical relationships and applying the same to the issue/problem (Adeyemi and Adeyemi, 2014). It is related to a students' ability to do mathematical operations quickly and accurately. The sub-set assesses how well a student is able to solve problems covering four primary arithmetic operations like addition, subtraction, multiplication and division including ratio, percentage, square and cube roots, linear equations, speed and factorization among others.

Spatial aptitude is related to the capacity to mentally manipulate actual materials through imagining (Adesoji and Oginni, 2012). A student in this ability test is required to quickly judge how an object would look like when constructed in a given way. It is assessed through items in which the need to determine quickly how the figure will look like when seen through a mirror and how a figure will look when folded in a particular way. Perceptual aptitude refers to a person's ability to quickly, accurately and meaningfully compare visual information, that is, letters, numbers, objects, pictures or patterns (Adeyemi and Adeyemi, 2014). The sub-set assesses how the students rapidly compare the paired group of letter or

numbers and identify the similarities or differences. DAT is administered for different purposes.

Some schools administer aptitude tests to students beginning in elementary school. Along with intelligence tests and achievement tests that measure student mastery of academic content, aptitude tests may be used to determine placement in gifted and talented programs or other specific educational tracks. For example, the Modern Language Aptitude Test (MLAT) measures a student's potential for successfully mastering foreign languages. Aptitude tests can also help determine if a student needs special education services. For older students, spatial relations to language usage. can help administrators make curricular recommendations. Counsellors might use high scores in a test in mechanical reasoning, for example, to guide a student toward courses that prepare them for engineering or designing studies in college. Students who score well in tests measuring speed, accuracy, and problem-solving might decide to choose coursework in computer science, finance, or other fields requiring attention to detail. DAT therefore is very necessary as it predicts academic achievement in different disciplines (Anazia, 2019; Curabay, 2016; Farida, 2020).

The judgement regarding the results of empirical studies on the prediction of academic achievement by differential aptitude is not conclusive or collectively exhaustive. This is because, aptitude is both innate and acquired, hence differs for students in different geographical location, level of education and subject areas such as Biology. Most importantly, it was found that most studies on differential aptitude focused on students in the university. Little or no studies have been conducted on the prediction of achievement in Biology by students' differential aptitude at the secondary level of education. None of such studies to the researcher's knowledge have been conducted in Anambra state secondary schools in the subject area of Biology. The need arises therefore, to determine the prediction of achievement in Biology by students' differential aptitude.

PURPOSE OF THE STUDY

The purpose of the study was to determine if differential aptitude and cognitive engagement are predictors of secondary school students' achievement in Biology in Onitsha Education Zone. Specifically, the study determined the:

- ✓ Predictive power of students' differential aptitude on achievement scores in Biology.
- ✓ Relative contribution of the dimensions of differential aptitude (language aptitude, abstract reasoning, verbal reasoning, mechanical reasoning, numerical aptitude, spatial aptitude and perceptual aptitude) to the prediction of students' achievement scores in Biology.

RESEARCH QUESTIONS

The following research questions guided the study:

- ✓ What is the predictive power of students' differential aptitude scores on achievement scores in Biology?
- ✓ What are the contributions of the dimensions of differential aptitude (language aptitude, abstract reasoning, verbal reasoning, mechanical reasoning, numerical aptitude, spatial aptitude and perceptual aptitude) to the students' achievement scores in Biology?

HYPOTHESES

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

- ✓ Students' differential aptitude scores is not a significant predictor of their academic achievement scores in Biology.
- ✓ The contributions of the dimensions of differential aptitude (language aptitude, abstract reasoning, verbal reasoning, mechanical reasoning, numerical aptitude, spatial aptitude and perceptual aptitude) to students' academic achievement scores in Biology are not significant.

II. 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 Differential Aptitude Test (DAT). DAT in its fifth edition was published in 1990 but was originally developed in 1947 by US psychologists George Kettner Bennett, Harold G. Seashore, and Alexander G. Wesman. In the present study, a standardized Differential Aptitude Test developed by the Indian Central Board of Secondary Education (CBSE) and National Council of Educational Research and Training (NCERT) called the Tamanna: An aptitude test for students at secondary school level was adopted. Tamanna is an aptitude test for students at secondary school level. DAT measured Language Aptitude, Abstract Reasoning, Verbal Reasoning, Mechanical Reasoning, Numerical Aptitude, Spatial Aptitude and Perceptual Aptitude. Each dimension has 30 questions. The complete test booklet for the test as produced by the developers, often administered as an online test, was adopted for test administration in this study. Thus, for the purpose of convenience of scoring and feedback, the researcher administered the instrument online at the developers' website for each student so as to ensure strict adherence to the norms. The instrument was validated by three lecturers in Departments of Science Education and Educational Foundations, Nnamdi Azikiwe University, Awka. The reliability of DAT was established using Kuder-Richardson Formula 20 as it is an objective test item that is scored dichotomously. The instrument was administered to 40 students and the KR-20 was used to computer the reliability. The coefficient of internal consistency obtained was 0.80.

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≤0.05) the null hypothesis was rejected and was accepted whenever Pvalue is greater than 0.05 (P>0.05).

III. RESULTS

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

Model	R	R^2	Adjusted R^2	Unstandardized coefficients (b)	Std. Error	Decision
Constant	.103[a]	.011	.009	60.390	12.778	Low positive relationship
Diff. Apt.				.171		

a. Predictors: (Constant), Differential Aptitude

Table 1: Prediction of Students' Achievement in Biology by Differential Aptitude

Table 1 shows a low positive relationship (R = 0.103) exists between students' differential aptitude and their achievement in biology. The R-Square value of 0.011 indicates that 1.1% of the variance in biology scores is predicted by differential aptitude.

Research Question 2: What are the contributions of the dimensions of differential aptitude (language aptitude, abstract reasoning, verbal reasoning, mechanical reasoning, numerical aptitude, spatial aptitude and perceptual aptitude) to the students' achievement scores in Biology?

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	56.321	3.454		16.304	.000
	Language aptitude	.036	.069	.020	.521	.602
	Abstract reasoning	.052	.118	.016	.438	.661
	Verbal reasoning	.128	.080	.059	1.598	.010
	Mechanical reasoning	.017	.066	.009	.259	.795
	Numerical aptitude	.072	.062	.043	1.160	.247
	Spatial Aptitude	.030	.126	.009	.241	.810
	Perceptual Aptitude	.279	.048	.212	5.819	.000

a. Dependent Variable: Biology Achievement

Table 2: Contributions of the Individual Dimensions of Differential Aptitude in the Prediction of Achievement Scores in Biology

Table 2 shows the standardized beta coefficient which indicates correlation between variables. The unstandardized beta coefficient shows the prediction powers of each dimension of differential aptitude which indicates their relative contribution to achievement in biology. The table shows that language aptitude has a low positive predictive relationship (R = 0.020) with students' achievement in biology, abstract reasoning has a low positive relationship (R = 0.016) with achievement in biology, while verbal reasoning has a low positive relationship (R = 0.059) with achievement, mechanical reasoning has a low positive relationship (R = 0.009) with achievement, numerical aptitude has a low positive relationship (R = 0.043) with achievement, spatial aptitude has a low positive relationship (R = 0.009) with achievement, where perceptual aptitude has a low negative relationship (R = 0.212) with achievement in biology. Table 2 also reveals that language aptitude is contributes 0.036 to achievement in biology whenever a students' language aptitude increase by one unit. With a unit increase, abstract reasoning increases achievement by 0.052, verbal reasoning increases achievement by 0.128, mechanical reasoning increases achievement by 0.017, numerical reasoning increases achievement by 0.072, spatial aptitude increases achievement by 0.030 where perceptual aptitude increases achievement by 0.279. The order of relative contribution to achievement in biology from the highest to lowest by each dimension of differential aptitude is; perceptual aptitude (0.279), followed by verbal reasoning (0.128), numerical aptitude (0.072), abstract reasoning (0.052), language aptitude (0.036), spatial aptitude (0.030) and then mechanical reasoning (0.017).

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

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1285.174	1	1285.174	7.872	.005[b]
	Residual	119838.542	734	163.268		
	Total	121123.716	735			

a. Dependent Variable: Biology Achievement
b. Predictors: (Constant), Differential Aptitude

Table 6: ANOVA on Significance of Prediction of Achievement in Biology by Students' Differential Aptitude

Table 6 shows that differential aptitude is a significant predictor of achievement scores in biology F (1, 734) = 7.872, P (0.005) < 0.05. The null hypothesis was therefore rejected implying that differential aptitude is a significant predictor of secondary school students' achievement scores in Biology.

Since differential attitude 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 = 60.390 and b value = 0.171 is:

BI = 60.390 + 0.171(DA)

Where, BI = Biology Achievement and DA = Differential aptitude

Hypothesis 2: The contributions of the dimensions of differential aptitude (language aptitude, abstract reasoning, verbal reasoning, mechanical reasoning, numerical aptitude, spatial aptitude and perceptual aptitude) to students' academic achievement scores in Biology is not significant.

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6613.814	7	944.831	6.007	.000[b]
	Residual	114509.902	728	157.294		
	Total	121123.716	735			

a. Dependent Variable: Biology Achievement

b. Predictors: (Constant), Perceptual Aptitude, Mechanical reasoning, Language aptitude, Spatial Aptitude, Abstract reasoning, Verbal reasoning, Numerical aptitude

Table 7: ANOVA on Significance of Prediction of Achievement in Biology by the Individual Dimensions of Differential Aptitude

Table 7 shows that all the individual dimension of differential aptitude jointly predicted the students' achievement scores in biology significantly F (1, 728) = 6.007, P (0.000) < 0.05. However, data contained in Table 2 shows the significance of the contributions of the individual dimensions to the prediction of achievement scores in biology.

Table 2 shows that language aptitude is not a significant predictor of achievement scores in biology, t = 0.521, P (0.602) > 0.05, abstract reasoning is not a significant predictor of achievement scores in biology, t = 0.438, P (0.661) > 0.05, verbal reasoning is a significant predictor of achievement scores in biology, t = 1.598, P (0.010) < 0.05, mechanical reasoning is not a significant predictor of achievement scores in biology, t = 0.259, P (0.795) > 0.05, numerical aptitude is not a significant predictor of achievement scores in biology, t = 1.160, P (0.247) > 0.05, spatial aptitude is not a significant predictor of achievement scores in biology, t = 0.241, P (0.810) > 0.05 and perceptual aptitude is also a significant predictor of achievement scores in biology, t = 5.819, P (0.000) < 0.05. Thus, the only significant contributors to the achievement of students in biology in order of significance are perceptual aptitude and verbal reasoning. However, since the joint prediction of all the dimensions of differential aptitude in the prediction of achievement score in biology is significant, the regression model ($Y= a + bX_1 + cX_2 + dX_3 + eX_4 + fX_5 + gX_6 + hX_7$) for the prediction of achievement score in biology as can be derived from Table 2, where constant = 56.321 and b value = 0.036, c value = 0.052, d value = 0.128, e value = 0.017, f value = 0.072, g value = 0.030 and h value = 0.279 is:

BI = 56.321 + 0.036(LA) + 0.052(AR) + 0.128(VR) + 0.017(MR) + 0.072(NA) + 0.030(SA) + 0.279(PA)

Where, BI = Biology Achievement and LA = language aptitude, AR = abstract reasoning, VR = verbal reasoning, MR = mechanical reasoning, NA = numerical aptitude, SA = spatial aptitude, PA = perceptual aptitude.

IV. DISCUSSION

The study showed that differential aptitude has a low positive relationship with achievement, and significantly predicts 1.1% of students' achievement score in biology. The only significant contributors to the achievement of students in biology in order of significance are perceptual aptitude and verbal reasoning. The significant predictive powers of differential aptitude can be attributed to the fact that students' achievement which are dependent on interest in learning, their motivation and extent of engagement in learning are all influenced by differential aptitude. Knowing one's aptitude to be high in numerical aptitude, quantitative aptitude and abstract reasoning can become a potent factor in students' interest in mathematical aspect of biology like calculations on population density and mathematics itself. A high verbal aptitude is necessary to the understanding of concept and self-expression and may give students a better motivation to study and in turn attain high academic achievement. This may be different for a student who perceives a low differential aptitude. For instance, having a very low abstract reasoning and verbal aptitude could be a sufficient factor for students to shy away from science subject such as biology.

Each differential aptitude is need for different discipline, however, some are more significantly important than other for certain subjects. Knowledge of one's aptitude may become a determinant for students' choice of career. Thus, given an aptitude level for which a student does not find sciences suitable, such a student may not thrive well in biology as well. To do so, a student must possess high levels of perceptual aptitude and verbal reasoning. Information about aptitude helps a student to determine their academic strength. Abilities bordering on high perceptual and verbal aptitude could therefore predispose a students' mind to want to study biology to a point greater achievement, knowing they have the abilities for such academic accomplishment. Since verbal reasoning has to do with ability to solve problems by understanding the meaning and ideas framed in words, it is necessary for students' understanding of biology which often give relational historic developments like in organisms and species, genetics and also important for biology terminologies and their usage in descriptive of biological processes.

The finding of the study is in line with the findings of Amanda (2007) that a significant positive relationship exists between differential aptitude and achievement. The finding of the study is in line with the finding of Farida (2020) the DAT test can predict the success of the study in the psychology study program. The findings of the study contradicts the findings of Omizo (1998) that numerical ability and abstract reasoning scores were correlated respectively, with performance in science courses and CGPA. The findings of Anazia (2019) also contravene the findings of the study when it was reported that quantitative and verbal aptitudes have predictive power on the performance of senior secondary school students in Economics.

V. CONCLUSION

The study concluded that differential aptitude is significant predictors of students' achievement in Biology. Again, high aptitudes in verbal reasoning and perceptual aptitude are the mostly needed if a students must attain good academic achievement in biology.

VI. RECOMMENDATIONS

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

- ✓ Teachers of biology at secondary schools should give students assignments that border on verbal and perceptual aptitudes to help them exercise these abilities in order to improve biology achievement.
- ✓ Secondary school counsellors should develop tasks aimed at helping biology students develop and improve their mastery of verbal and perceptual aptitudes.

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