



Chemistry Students' Cognitive Styles and Academic Achievement in Secondary Schools in Nigeria

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Abstract

The study examined the relationship between the cognitive styles of secondary school students in the Awka Education Zone of Anambra state, Nigeria, and their academic achievement in Chemistry. It also considered the moderating influence of gender on the relationship between these variables. A Chemistry Achievement Test (CAT) proforma and the Group Embedded Figure Test (GEFT) were the instruments used to collect the data. The study problems were addressed using the Pearson product-moment coefficient (r), coefficient of determination (r^2), linear regression, and the Hayes Macro Process with the hypotheses tested at the 0.05 significance level. The findings showed a strong positive correlation between secondary school students' academic achievement in Chemistry and their cognitive styles. Additionally, there is a moderately significant positive relationship between a student's gender and their academic achievement in Chemistry at the secondary school level in terms of cognitive style. It was suggested that chemistry lessons be designed to identify each student's preferred cognitive style and work to meet their needs. Also, Chemistry pre-service and in-service teachers should be trained to create an appropriate classroom environment that integrates variables such as cognitive styles and gender-unbiased teaching methods in the learning process.

Keywords: Cognitive styles, academic achievement, secondary school students, and chemistry

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Introduction

Chemistry is an essential component of the science curriculum for secondary schools in Nigeria. It serves as an introduction to a wide range of basic ideas that help students gain knowledge and abilities relevant to higher education. However, students' performance in chemistry has been below average and erratic despite the subject's relevance. The West African Examination Council (WAEC) Chief Examiner's findings on the performance of Nigerian Chemistry students have been inconsistent in recent years. The credit percentages that were earned were 60.60, 57.74, 62.68, 61.95, 54.59, 59.00, and 61.50, as per the WAEC Chief Examiner's report (2015–2021). Numerous factors have been identified as contributing to this ugly trend, according to Nwafor, Odukwe, and Achugbu (2024), Nwafor, Eke and Ibe (2023), Ezeudu, Nwafor, Abaeme, Alabi, Chukwuka and Ikuelogbon (2019) and Akanbi and Kolawole (2014). These factors include test anxiety, cognitive style, self-esteem, lack of qualified chemistry teachers, and poor teaching methods. Students' cognitive styles are the subject of this study.

According to Ifelunni (2019), cognitive style is the individual variations in how students reason, think, remember, comprehend, and translate situations for problem-solving. The various distinct aspects or attributes that learners bring to learning tasks—physical, social, intellectual, etc.—play crucial roles in their learning. It is a person's most reliable method of information processing and learning. Numerous other contemporary psychological fields, such as educational psychology, social psychology, personality psychology, abnormal psychology, developmental psychology, and economics, have included a large portion of the research from cognitive psychology. The relationship between students' achievement and their cognitive styles has been the subject of empirical research. Sakina, Dewi, and Putri (2017), for example, conducted research on the relationship between students' reading comprehension and cognitive styles. Students' reading comprehension and cognitive style were found to be significantly correlated. Additionally, in Jigawa State, Nigeria, a study conducted by Sara, Maruta, and Olarinoye (2016) using senior secondary school biology students revealed a connection between cognitive styles and achievement in science process skills. Sharma and Pooja (2018) investigated the association between secondary school students' cognitive styles and academic achievement and discovered a strong positive relationship between the two. According to Okeke (2016), students' academic performance in physics is significantly influenced by their cognitive styles. Conversely, Ahiauzu (2017) found no significant relationship between students' academic achievement and cognitive style. In Malaysia, Jantan (2014) conducted a study to ascertain the relationship between year 6 students' cognitive styles and their mathematical achievement. The results showed that students' achievement in mathematics and their cognitive styles had a low positive association. Boys and girls in the school also differed significantly in their cognitive styles. The researchers felt it was appropriate to look at the relationship between students' academic achievement in chemistry and cognitive styles in light of the contradictory claims regarding this relationship as well as the paucity of literature on the subject. Moreover, gender is a significant element that might impact pupils' academic performance, particularly in Nigeria due to its multiethnic nature.

Research on the impact of gender on students' achievement in science, particularly chemistry, has drawn the attention of researchers in Nigeria. Male students are more drawn to science and technology disciplines than their female counterparts because science subjects are

perceived as having a masculine appeal in Nigeria (Ogunleye & Babajide, 2011); (Hakimi et al., 2024). Furthermore, conflicting research has been done on the moderating role of gender on cognitive styles and achievement. For example, Oladotun (2020) found that academic achievement in summary writing is positively and significantly predicted by both cognitive style and gender. According to Zulai, Owonwami, Gideon, and Lakam (2021), there is a substantial and positive statistically significant correlation between senior secondary school students' cognitive styles and their academic achievement in biology. Conversely, Samuel and Musa (2019) discovered that male students considerably outperformed female students in Basic Science across both the Field Dependence (FD) and Field Independence (FI) groups. Amuda and Akanbi (2021) found no statistically significant difference in the strength of the correlation between students' cognitive style and achievement in physics, based on gender among other factors. Similarly, Okoye (2016) used a sample of 265 SSII biology students (141 males and 124 girls) selected from government-owned schools and employed a causal-comparative research design. The results showed that neither gender nor cognitive style had a significant impact on students' biology achievement scores. The researchers looked into the moderating effect of gender on the relationship between cognitive styles and students' achievement in Chemistry as a result of these contradictory findings, which may have been caused by the use of different class levels, subjects, content areas, and research methodologies. Therefore, the objectives of the study were to determine the relationship between the cognitive styles of secondary school students and their academic achievement in chemistry and to ascertain the moderating influence of gender on the relationship between the cognitive styles of secondary school students and their academic achievement in chemistry.

Methodology

Research Design

A correlation survey research design was used for the study. This design was considered appropriate because, according to Nworgu (2018), a correlation study seeks to establish what relationship, association, or covariance exists between two or more variables, which aligns with the study objectives.

Participants

The Awka Education Zone in Anambra State served as the study's location. 2,273 senior secondary II (SSII) chemistry students in the Zone made up the population. 350 SSII chemistry students from five government-owned secondary schools in the Awka Education Zone made up the sample size. The proportionate stratified random technique was utilized to sample the study's student population, while the five schools were chosen using a simple random technique to sample one school from each of the five Local Government Areas that comprised the Zone.

Instruments

The Group Embedded Figure Test (GEFT), which was adapted from Witkin, Ottman, Raskin, and Karp (1971), and the Chemistry Achievement Test (CAT) proforma were the two instruments employed for data collection. Chemistry students' achievement scores for the first, second, and third terms were obtained using the CAT proforma. Each student's average score

was then computed and correlated with their GEFT scores. Witkin, Ottman, Raskin, and Karp (1971) published the nonverbal GEFT speed test, which is used to assess students' cognitive styles. Students' ability to identify a simple form inside a complicated pattern is assessed with this test. The range of a GEFT score is 0 to 18. Students with scores of 0–6 are categorized as field-dependent (FD), those with scores of 7–12 as field intermediate (F, INT), and those with scores of 13–18 as field-independent (FI). The original instrument's reliability index, calculated using the test-retest method over three years, was 0.89. Two specialists from Nnamdi Azikiwe University in Awka, one from the Department of Education Foundations (Measurement and Evaluation Unit) and one from the Department of Science Education (Chemistry Education Unit), face validated the instrument.

Data Collection Procedure

The researchers employed spot-on instrument administration (GEFT) to guarantee a 100% return. First, the researchers asked for the student's permission, assisted by the regular chemistry teachers of the schools included in the sample. A sample of those who agreed to take part in the study (about 69% of them) was taken, and the instrument's instructions were also given. After the GEFT was administered, the students' CAT scores were collected from their regular chemistry teachers.

Data Analysis Procedure

Data were analyzed using linear regression, with the following decision rules for interpreting the correlation coefficients based on Gay, Mills, and Airasian (2011): $-.35$ to $+.35$ = weak/no correlation; $\pm.36$ to $\pm.65$ = moderation correlation; and $\pm.65$ to ± 1.00 = strong correlation. Pearson product correlation coefficient (r) and coefficient of determination (r^2) were used to answer the research question, while regression ANOVA and Hayes Process Macro were used to test the hypotheses at a 0.05 level of significance.

Results

Based on the objectives of the study, the following results were obtained and presented below. Tables 1 and 2 were used to show the result of the relationship between the cognitive styles of secondary school students and their academic achievement in chemistry.

Table 1: Regression analysis of the relationship between the cognitive styles of secondary school students and their academic achievement in chemistry

Model	r	r^2	Adjusted r^2	Std. Error of the Estimate	Decision
1	.382 ^a	.146	.144	14.77231	Positive Moderate relationship

a. Predictors: (Constant), GEFT

b. Dependent Variable: CAT

The correlation coefficient and coefficient of determination (r^2) as seen in Table 1 obtained for the relationship between the cognitive styles of secondary school students and their academic achievement in chemistry are .382 and .146 respectively. This demonstrates that there is a moderately positive association between the cognitive styles of secondary school students and their academic achievement in Chemistry, with cognitive styles accounting for 14.6% of the

difference in Chemistry achievement among these students. The hypothesis below was developed and put to the test to ascertain whether this association is significant.

Table 2. ANOVA Regression analysis on the significant relationship between secondary school students' cognitive styles and their academic achievement in Chemistry

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	12987.983	1	12987.983	59.518	.000 ^b
	Residual	75940.957	348	218.221		
	Total	88928.940	349			

a. Dependent Variable: CAT

b. Predictors: (Constant), GEFT

In Table 2 above, the null hypothesis was rejected because, at 59.518 F-value, a probability value of .000 was obtained which is less than the 0.05 level of significance. Therefore, a significant correlation ($P < 0.05 = .000$) has been found between the cognitive styles of secondary school students and their academic achievement in Chemistry, suggesting that cognitive style had a major role in the student's academic achievement in Chemistry.

To result in Table 3 was used to determine the moderating influence of gender on the relationship between the cognitive styles of secondary school students and their academic achievement in chemistry.

Table 3. Hayes process analysis of the moderating influence of gender on the relationship between the cognitive styles of secondary school students and their academic achievement in chemistry

Model Summary						
r	r ²	MSE	F	df1	df2	p
.4431	.1963	206.5663	28.1702	3.0000	346.0000	.0000

The data in Table 3 reveals that the correlation coefficient and coefficient of determination (r^2) obtained for the moderating influence of gender on the relationship between the cognitive styles of secondary school students and their academic achievement in chemistry are .4431 and .1963 respectively. Additionally, the hypothesis indicates that the moderating influence of gender on the relationship between secondary school students' cognitive styles and their academic achievement in Chemistry is significant ($P < 0.05 = .000$), indicating that the gender of secondary school students has a significant influence concerning the relationship between cognitive styles and students' academic achievement in Chemistry in the Awka Education Zone of Anambra State, Nigeria. These findings suggest a positive moderate relationship between cognitive styles and students' achievement; also 19.63% of students' achievement in Chemistry can be attributed to their cognitive styles.

Discussion

The study's findings showed a moderately positive correlation between secondary school students' cognitive styles and their chemistry academic achievement. According to the hypothesis, secondary school students' academic achievement in Chemistry is significantly correlated with their cognitive styles. This might be because of the student's capacity for critical thought, reasoning, and understanding of chemistry in a classroom setting—all of which are crucial for enhancing student achievement. This is in line with Kolb (1984) experiential learning theory which affirms that students' achievement and learning are enhanced through a combination of reflective observation, concrete experience, active learning via experimentation, reflective observation, and abstract conceptualization. Therefore, Chemistry instructions need to emphasize the combination of these variables to develop students' cognitive styles and invariably their achievement. This is consistent with the discovery made by Sara, Maruta, and Olarinoye (2016) that among Jigawa State's senior secondary school biology students, there is a noteworthy positive correlation between cognitive styles and achievement in science process skills. Similar findings were made by Sharma and Pooja (2018), who looked at the relationship between secondary school students' academic achievement and their cognitive styles (field-independent & field-dependent). They discovered a significant positive correlation. Furthermore, the results corroborate the claims made by Ezike (2017) that cognitive styles have a major impact on biology students' academic performance. On the other hand, Ahiauzu (2017) found no evidence of a relationship between students' achievement and cognitive types. Ipek (2011) discovered that there was no discernible correlation between the field reliance cognitive styles and text density levels on reading comprehension scores. Furthermore, in contrast to the results of this investigation, Jantan (2014) proposed a weakly positive link between students' cognitive styles and their achievement in mathematics. These findings imply that instruction in chemistry should be designed with an awareness of each student's unique cognitive style in mind, to improve it and student-centered learning should be promoted to enhance students' cognitive styles and achievement in chemistry instruction. These can be achieved through seminars, workshops, and conferences (Gusmaweti et al., 2023). The findings of the research will help curriculum planners in the area of curriculum planning and development, by ensuring that the school curriculum is planned and developed concerning the students' cognitive abilities. Also, findings will inspire and motivate students to develop their cognitive abilities since there is a relationship between cognitive styles and achievement.

Furthermore, the results showed a moderately positive correlation between students' cognitive styles and achievement as moderated by gender, with 19.63% of students' achievement in Chemistry attributable to their cognitive styles. Subsequent investigation also revealed a strong moderating effect of gender on the relationship between the academic achievement in Chemistry of secondary school students and their cognitive styles. This can be a result of the lecture method of instruction, which discourages engagement from the students. This result is consistent with Oladotun's (2020) discovery that gender and cognitive style are significant and positive predictors of students' achievement in summary writing. Furthermore, investigations conducted by Zulai et al. (2021) and Aniodoh and Eze (2014) found a significant and positive correlation between students' cognitive styles and their academic achievement in science and biology, respectively. The results, however, contradict those of Amuda and Akanbi (2021) and Okoye (2016), who found no connection between achievement and students' cognitive styles based on gender. This implies that teachers, both pre-service and in-service, in the field of chemistry should receive training on how to create classrooms that incorporate gender-unbiased teaching styles and cognitive styles into the teaching and learning process.

Conclusions

The conclusion drawn by the researchers was that secondary school students' cognitive styles and gender play a major role in improving their academic achievement in Chemistry. As a result, problem-solving and decision-making skills should be included in chemistry instruction without sacrificing the advancement of students' knowledge and attitudes. As a result, educators, curriculum developers, and school guidance and counseling professionals must recognize and incorporate students' cognitive styles into their materials and procedures. Future researchers could explore the place of cognitive ability and achievement in higher education. Also, future research on interventions towards enhancing students' cognitive ability using experimental research design is encouraged to promote understanding of the variables of the study. The sample size used in this study which was obtained from only five government-owned secondary schools limits the generalizability of the results to the Nigeria population. Hence, a replication of the study in a different context is encouraged.

Conflicts of Interest

The authors declare no conflict of interest.

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