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Influence of Cognitive Style on Students' Academic Achievement in Quantitative Analysis, Chemical Reaction and Electrolysis in Kogi State

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ABSTRACT

This paper investigated cognitive styles on students' learning outcome in quantitative analysis, chemical reaction, and electrolysis. An ex post facto design was utilized with population of 2,519 SSSII chemistry students in the 'Ankpa Education Zone, Kogi State'. Sample size 268, drawn from six government mixed schools participated in the project. 'Group Embedded Figure Test (GEFT), and Chemistry Achievement Test (CAT)' were the utilized instruments. CAT was face-validated by three experts and was pilot tested, and yielded reliability coefficient of 0.86, while GEFT yielded 0.89 as established by Oltman, Raskin, and Witkin in 1971. 'Mean and standard deviation were used to answer the research questions, while t-test statistics were used to test the hypotheses at the 0.05 level of significance'. The results showed a significant difference between the mean achievement scores of field dependent and field independent students in quantitative analysis in favour of field independent. 'No significant difference in the mean achievement scores of field dependent and field independent students in chemical reactions, and there was a significant difference between the mean achievement scores of field dependent and field independent students in Electrolysis'. We concluded that field-independent students achieved better than field-dependent students and it was recommended for attention to be given to both group of students to ensure improve learning outcome.

Keywords: Achievement, Chemistry, Cognitive style, Field dependent and Field independent students.

INTRODUCTION

Chemistry is the branch of science that deals with the study of matter, its composition, structure, properties and the changes it undergoes during chemical reactions. It is concerned with the laws and principles governing these changes (Nwafor et al., 2024). Chemistry plays crucial roles in developing students' analytical thinking, problem-solving, critical reasoning, and scientific skills. It helps learners understand everyday phenomena, interpret scientific information, and apply mathematical principles to solve chemical problems. Furthermore, chemistry provides the foundation for careers in medicine, pharmacy, agriculture, and other science-related fields (Ukala & Adigwe, 2021). These benefits highlight the importance of examining how students' cognitive styles influence their achievement in chemistry.

Despite these importance placed on chemistry, among other science subjects, the poor achievement of chemistry students has been a concern to researchers, and many factors, like cognitive style, gender, instructional resources, location, education policy, among others, have been considered to influence the achievement of chemistry. Hence, the focus on students' cognitive style is a paradigm shift in academic achievement. There are various theoretical classifications of cognitive style, but the one which has probably gained the most attention in the literature is Field Dependence (FD) and Field Independence (FI) (Xie et al., 2025).

Cognition refers to a set of mental activities involved in acquiring and using knowledge, including awareness, perception, reasoning, and judgment. Cognitive style describes the individual differences in how people prefer to organize, interpret, and process information and experiences. It is different from learning style, which relates to the individual preferences and abilities that influence how learners receive, understand, and process learning materials. However, the present study focuses on cognitive style rather than learning style.

Idika (2017) described cognitive style as a broad concept that explains the different ways individuals perceive, organise, classify, and interpret information from their environment. Similarly, Nwafor et al. (2024) viewed cognitive style as an individual's usual way of receiving, interpreting, and processing information. Cognitive style is generally classified into two major categories: Field-Dependent (FD) and Field-Independent (FI).

Field-dependent individuals often require sufficient details and guidance when dealing with problems. They are generally more comfortable with activities that involve social interaction and collaboration with others. They may also be more sensitive to criticism and external opinions. Such individuals tend to prefer occupations and tasks that involve interpersonal relationships rather than activities that require independent analysis. According to Idika (2017), field-dependent individuals are strongly influenced by their environment and external stimuli, with less emphasis on independent judgement. They may also experience difficulties when organising new information independently or connecting it with previously acquired knowledge. Generally, field-dependent individuals are sociable, enjoy working with others, and may find abstract concepts and theoretical tasks challenging.

Field-independent (FI) individuals generally opt for approach learning and problem-solving tasks independently. They tend to rely on personal judgement and are more comfortable identifying solutions without depending heavily on external assistance. Somaa (2024) explained that field-independent learners are usually independent in their thinking and prefer solving problems on their own. They often favour individual learning activities, while field-dependent learners are more inclined towards social interaction and group activities. Field-dependent individuals generally seek more interaction with others and are influenced by their social environment. Somaa (2024) further observed that field-dependent individuals are often extroverted, externally motivated, and influenced by their peers and authority figures. In contrast, field-independent individuals are more likely to be introverted, internally motivated, and independent in making decisions. They also tend to prefer competitive activities, personal choices, and the freedom to organise their learning activities and work independently.

Individuals with a FI-CS possess certain psychological and social characteristics, particularly analytical ability and self-direction. They are generally capable of identifying and solving problems even when sufficient information is not readily available. They are also less likely to be influenced by criticism or the opinions of others (Xie et al., 2025). Samuel and Okonkwo (2021) explained that field-dependent and field-independent cognitive styles represent differences in learners' perception and information-processing abilities, which influence how they receive, interpret, store, and retrieve information. Field-independent individuals generally enjoy working with abstract concepts and theories, prefer independent activities, and demonstrate strong personal ambition. They also tend to have a clear understanding of their personal needs, emotions, and goals and are more likely to make decisions based on their own judgement rather than external opinions. Since cognitive style may influence how students understand and process academic information, it is important to examine how FD and FI cognitive styles relate to students' academic achievement in chemistry.

Achievement refers to the ability of an individual to overcome challenges and difficulties in order to accomplish a specific goal. It involves making necessary adjustments and applying appropriate knowledge and skills to overcome obstacles. Samuel and Okonkwo (2021) described achievement as the ability to identify and provide solutions to problems through the effective application of acquired knowledge. In this regard, achievement involves not only acquiring relevant knowledge but also developing the ability to apply such knowledge effectively in solving practical problems.

Reports from the West African Examinations Council (WAEC) have consistently highlighted concerns about students' academic performance in chemistry (WAEC, 2023). The reported poor achievement of students in chemistry has continued to attract the attention of researchers and education stakeholders. In view of this concern, the present study seeks to examine students' cognitive styles as possible factors associated with their achievement in selected areas of chemistry. Understanding 'the relationship between cognitive style and academic achievement' may provide useful information for improving chemistry teaching and learning.

Achievement can also be understood as the successful completion of a challenging task through effort, ability, practice, and perseverance. Samuel and Okonkwo (2021) viewed achievement as an outcome attained through the application of knowledge, skills, and sustained effort. They also explained that achievement can be used to assess and compare individuals' abilities across different academic disciplines. In the educational context, academic achievement refers to students' level of performance as measured through standardised tests and other forms of educational assessment.

Literatures shows that students' cognitive styles had a significant influence on their academic performance. Idika (2017) found that students with analytical (field-independent) cognitive styles performed significantly better in chemistry than those with relational (field-dependent) and inferential cognitive styles. This finding implies that students' preferred ways of processing and organising information may be related to their achievement in chemistry. Also, Sharma and Pooja (2018) found a significant positive relationship between cognitive style and students' academic achievement. Similarly, Nwafor et al. (2024) findings indicated that cognitive style had a significant influence on students' academic achievement in chemistry. This finding further demonstrates the importance of considering individual differences in information processing when examining students' learning outcomes in science subjects. Moreso, Atsuwe and Mtoh (2019) revealed in their study that field-independent students performed better in physics than their field-dependent counterparts, and field-independent students demonstrated higher retention levels than field-dependent students.

Despite the importance of chemistry in nation's development, students' achievement in the subject has continued to generate concern among educators and researchers, as reflected in the West African Examinations Council (WAEC, 2023) Chief Examiners' Report. This persistent challenge raises questions about the factors that may contribute to students' poor achievement in chemistry beyond the teaching methods and instructional resources commonly examined. One of such factors is students' cognitive style. Although previous studies (Ukala et al, 2026, Nwafor et al. 2024, Atsuwe & Mtoh, 2019, Idika, 2017) have established the relevance of cognitive style to students' academic achievement in science subjects, there is still a need to examine how these cognitive styles affect students' achievement particularly in chemistry. Hence, this article examined the effect of FD and FI cognitive styles on students' academic achievement in chemistry, with a view to establishing whether differences in students' cognitive

styles account for variations in their academic performance in some selected concepts in chemistry.

Research Questions

1. What is the achievement mean score of FD and FI-CS of chemistry learners' in quantitative analysis?
2. What is the achievement mean score of FD and FI-CS of chemistry learners' in chemical reaction?
3. What is the achievement mean score of fie FD and FI-CS of chemistry learners' in electrolysis?

Hypotheses

H01: the difference in mean achievement score between FD and FI-CS learners' in quantitative analysis is not significant.

H02: the difference in mean achievement score between FD and FI-CS learners' in chemical reaction is not significant.

H03: the difference in mean achievement score between FD and FI-CS learners' in electrolysis is not significant

METHOD

Ex-post facto research design was utilized for the study. The design is appropriate for this study because students' cognitive styles (field-dependent and field-independent) are naturally occurring characteristics that cannot be manipulated by the researcher. 'The population of the study comprised 2,519 senior secondary school two (SSII) students' who offered chemistry in the Ankpa Education Zone of Kogi State. Ankpa Education Zone has three local government areas (Ankpa = 1562, Olamaboro = 525, and Omala = 432) with 43 public secondary schools. The names of the public secondary schools and the number of SSSII students who offer chemistry were collected from the Ministry of Education office in Ankpa Local Government Secretariat, Kogi State, Nigeria.

The sample size for the study was 268 SSSII chemistry students. The sample size consisted of 143 Field Independent and 125 Field Dependent students. Proportionate stratified random sampling was used for the study. Proportionate stratified random sampling ensures that the sample fairly represents the population and that smaller groups are adequately represented. (Creswell and Creswell, 2018). The proportion 0.106 was first determined using the ratio of sample size and the entire population. Ankpa Education Zone has three local government areas, Ankpa, Olamaboro and Omala, which represent strata, proportion 0.106 was also expressed in percentage as 10.6% for each local government. The sample size for each stratum was computed from the population in each stratum 10.6% of 1562 gave (166) from Ankpa, 10.6% of 525 gave (56) from Olamaboro, and 10.6% of 432 gave (46) from Omala Local Government areas.

Students were classified into FD and FI CS based on their ability to identify and trace simple figures hidden within complex designs. Each student received a booklet containing 25 complex figures arranged into three sections. The first section contained seven practice items to familiarize students with the test procedure, while the second and third sections contained nine items each, making a total of 18 test items. Only the 18 items in the second and third sections were used for assessment. Each correctly identified and traced figure received one mark, while an incorrect response received zero. Students who scored between 0 and 8 were classified as field-dependent, whereas those who scored between 9 and 18 were classified as FI. 'The Group Embedded Figures Test (GEFT) was originally developed by Oltman, Raskin, and Witkin in 1971' in the United States.

The Chemistry achievement test (CAT) was developed by the researcher from the New School Chemistry textbook, Sixth Edition (2011). The Chemistry achievement test contained SSS1 to SSS11 chemistry contents, three topics in chemistry (quantitative analysis, chemical reactions and electrolysis) were chosen. CAT comprises 50 multiple choice questions with options A-D made up of three clusters: A, B and C. Cluster A and B consist of 15 items in each cluster, while cluster C consists of 20 items. All items from 1-50 carry one (1) or zero (0) score for each question answered correctly or incorrectly. The chemistry achievement test items were designed to measure students' academic achievement in three selected topics: quantitative analysis, chemical reactions, and electrolysis.

The Group Embedded Figure Test (GEFT) was adopted by the researcher and was not subjected to validation. But face and content validation were established for CAT by three experts, two from the measurement and evaluation unit and one from the chemistry education unit, all from the Department of Science Education, University of Nigeria, Nsukka. Collected data was analyzed using mean and standard deviation for the researches questions while t-test was utilized to test the hypothesis at 0.05 level of significance.

RESULTS

Table 1: Mean and standard deviation scores of FD and FI students in quantitative analysis & t-test

Cognitive Style	N	Mean	Std. Deviation	df	t-value	Sig.(2-tailed)
Field Dependent	123	9.83	1.89	266	-4.50	0.000
Field Independent	145	10.87	1.88			

Table 1 reveals the mean achievement and standard deviation scores of students in FD and FI-CS in quantitative analysis. FD had a mean achievement score of 9.83 with a SD of 1.89, while FI had a mean achievement score of 10.87 and a SD of 1.88. The low SD of FI students against the SD of FD students shows that their scores clustered around the mean than FD scores.

Hypothesis one

Table 1 'shows that the probability value associated with the calculated t (-4.50) for the difference in the mean scores of FD and FI students' achievement in quantitative analysis is 0.00, and because the p-value < 0.05 alpha level, the null hypothesis was rejected'. Thus, difference between the mean achievement score of FD and FI-CS learners' in quantitative analysis.

Question Two:

Table 2: Mean and standard deviation scores of FD and FI students in chemical reaction

Cognitive Style	N	Mean	Std. Deviation	df	t-value	Sig.(2-tailed)
Field Dependent	123	11.12	8.24	266	-.593	0.55
Field Independent	145	11.54	1.76			

Table 2 reveals that FD 'had a mean achievement score of 11.12 with a standard deviation of 8.24, while FI had a mean achievement score of 11.54 and a standard deviation of 1.76.' The 'standard deviation of field-independent students was lower than the standard deviation of field-dependent students'. This shows that the field-independent scores were closer together around the mean. That is, there is more variability among field-dependent scores than field-independent scores in chemical reaction.

Hypothesis two

Table 2 'shows the probability associated with the calculated value of t (-0.59) for the difference in the mean scores based on cognitive style, and because the probability value of 0.55 is > 0.05 alpha level, the null hypothesis was retained. Thus, the difference in mean achievement score between FD and FI-CS learners' in chemical reaction is not significant.

Question Three

Table 3: Mean and standard deviation scores of FD and FI learners in electrolysis' and t-test

Cognitive Style	**N**	**Mean**	**Std. Deviation**	**Df**	**t-value**	**Sig.(2-tailed)**
Field dependent	123	12.66	2.49	266	-5.26	.000
Field independent	145	14.24	2.43			

Table 3 shows the mean scores of both FD and FI chemistry students in electrolysis. Field dependent had mean achievement score of 12.66 with standard deviation of 2.49 while field independent had mean achievement score of 14.24 and standard deviation of 2.43. The overall mean score (12.66) of FD is less than mean score (14.24) of FI. The SD of FI students was lower than the SD of FD students. This shows that the field independent scores were closer together around the mean compare to field dependent scores. That is, there is slightly variability among field dependent scores than field independent in electrolysis.

Hypothesis three

Table 3 shows the probability associated with the calculated value of t (-5.25) for the difference in the mean ratings of field-dependent and field-independent. 'Since the probability value of 0.000 is less than the 0.05 level of significance, the null hypothesis was rejected, meaning that significant difference exist between the mean scores of field-dependent and field-independent chemistry students in electrolysis'.

DISCUSSION

The findings of the study shows that significant difference exist in the mean achievement scores of FD and FI chemistry students in quantitative analysis. This may be attributed to differences in how FD and FI students' process information, as field-independent students may demonstrate stronger analytical and problem-solving abilities required for solving quantitative chemistry problems. The findings of this study aligned with the findings of Musa and Samuel (2019), Idika (2017) who found that independent cognitive style students achieved significantly higher than their dependent cognitive style counterparts in sciences. In addition, Idika (2017) findings shows that cognitive styles significantly influence learners' academic performance in chemistry in favour of analytic (field independent), while cognitive perform significantly higher than relational (field dependent) and inferential ones.

The findings revealed further that no significant difference exist between the mean achievement score of FD and FI chemistry students in chemical reaction. The findings of this study corroborate with the findings of Samuel and Okonkwo (2021), which indicated that cognitive styles (Field dependence/Independence) was a significant predictor of scientific achievement in Male and female students. In contrary, Sharma and Pooja (2018), found that there is a significant positive relationship between cognitive styles (Field Independent & Field Dependent) and academic achievement.

Furthermore, the findings of this study revealed that there was a significant difference between the mean achievement scores of FD and FI chemistry students in electrolysis. The findings of this study are in line with Sharma and Pooja (2018), which revealed that there was a significant relationship between cognitive style and achievement. This findings support the findings of Nwafor et al. (2024) who reported that cognitive styles (Field dependence/Independence) has a significant influence on student academic achievement. Atsuwe and Mtoh (2019) revealed that FI students achieved better than the FD students in physics. Similarly, Musa and Samuel

(2019) also found that science students in the FI group achieved significantly better than those in the FD.

CONCLUSIONS

This study has shown that the cognitive style influences students' achievement in quantitative analysis, chemical reaction and electrolysis. It was noted that field independent students achieved better than field dependent students in quantitative analysis and electrolysis, but there was no significant difference in their achievement in chemical reaction.

Recommendations

1. This project should be replicated in other science subjects for better academic achievement among students both FD and FI.
2. Special attention should be given to FD students to ensure an improved learning outcome.

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