

Research Article

Investigation of perceived concept difficulty, interest and academic achievement in chemistry among secondary school students in Cross River State, Nigeria

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Abstract

This study investigated perceived concept difficulty, interest and academic achievement in Chemistry among secondary school students in Cross River State, Nigeria. The study was guided by one research question and one null hypothesis. An ex-post-facto research design was adopted. The population comprised 8,702 Senior Secondary School III Chemistry students, from which a sample of 1,150 students was selected using a multistage sampling technique. Three instruments were used for data collection: the Perceived Concept Difficulty in Chemistry Inventory (PCDCI), the Student Chemistry Interest Scale (SCIS), and the Chemistry Achievement Test (CAT). The instruments were validated by experts, and their reliability coefficients were 0.70, 0.90 and 0.72, respectively. Data were analyzed using descriptive statistics, multiple regression and Analysis of Variance (ANOVA) at the 0.05 level of significance. Findings indicated that students generally perceived Chemistry concepts as moderately difficult and moderately interesting. Perceived concept difficulty did not significantly influence students' academic achievement when considered independently. However, interest in Chemistry had a strong and significant influence on academic achievement, demonstrating its importance in improving learning outcomes. The combined influence of gender, school location, and age on academic achievement was statistically significant, indicating an interaction effect among these demographic variables. The study concluded that students' interest is a stronger predictor of achievement than perceived concept difficulty, while demographic factors jointly influence learning outcomes. It was recommended that teachers should adopt engaging instructional strategies and real-life applications to enhance students' interest, and educational stakeholders should address contextual disparities affecting Chemistry learning.

Keywords: Academic achievement, Age, Gender, Interest in Chemistry, Perceived concept difficulty and School location.

1. Introduction

Chemistry is a fundamental science that underpins technological innovation, industrial production, healthcare, agriculture and environmental sustainability. As a core subject in the senior secondary school curriculum, it equips learners with scientific knowledge, problem-solving skills and practical competencies required for science-related careers. Consequently, improving students' academic achievement in Chemistry has remained a priority for educators and policymakers worldwide. However, evidence from contemporary Chemistry education research indicates that many students continue to experience difficulties in mastering fundamental concepts, thereby limiting their academic success and progression into science-related fields (Stone, 2021).

Despite the importance of Chemistry, students' achievement in the subject remains unsatisfactory in many developing countries, including Nigeria. Contemporary studies attribute this challenge to a combination of cognitive, affective and contextual factors rather than instructional practices alone. Among these factors, perceived concept difficulty, students' interest and learner characteristics such as gender, school location and age have received considerable attention because they collectively influence students' understanding, engagement and academic performance. Understanding how these variables interact is therefore essential for developing evidence-based interventions that will improve Chemistry achievement among secondary school students in Cross River State,

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Nigeria (Oladejo, Ademola, Ayanwale & Tobih, 2023).

Perceived concept difficulty refers to learners' subjective evaluation of the complexity of specific Chemistry concepts based on their prior knowledge, learning experiences and confidence in understanding the subject matter. Chemistry concepts involving symbolic representations, mathematical calculations and microscopic processes are frequently perceived as difficult because they require learners to integrate multiple levels of scientific thinking. When students perceive concepts as excessively difficult, they often experience reduced self-confidence, increased cognitive load and lower engagement during instruction, which ultimately affect their academic achievement. Recent evidence indicates that learners who perceive lower cognitive and emotional barriers are more likely to adopt mastery-oriented learning strategies, demonstrate better conceptual understanding and achieve higher academic performance in Chemistry (Wilkes, Gamble & Rocabado, 2024).

Several Chemistry topics have consistently been identified as difficult by secondary school students. These include the mole concept, stoichiometry, thermochemistry, chemical kinetics, electrochemistry, chemical equilibrium, redox reactions and organic chemistry. Students' inability to understand these concepts contributes significantly to poor academic performance. Kyado, Achor and Adah (2021) reported that students' perceptions of difficult Chemistry concepts are influenced by contextual factors and that reducing perceived difficulty through effective instructional strategies, adequate learning resources and meaningful classroom experiences can significantly improve conceptual understanding and academic achievement. Similarly, Ahiakwo and Ene (2021) emphasized the need for instructional approaches that simplify abstract concepts and enhance students' conceptual understanding.

Students' interest is another important determinant of academic achievement in Chemistry. Interest motivates learners to participate actively in classroom activities, sustain attention, persevere when confronted with challenging learning tasks and develop positive attitudes toward the subject. Students who possess genuine interest in Chemistry are more likely to engage in practical activities, devote additional time to independent learning and achieve better academic outcomes than those with low interest. Recent empirical studies have shown that learner-centred instructional approaches, including inquiry-based learning, context-based teaching, collaborative learning, practical activities, continuous assessment and the integration of real-life applications, significantly enhance students' interest and subsequently improve academic achievement in Chemistry (Musengimana, Kampire & Ntawiha, 2021; Getu, Mebrahitu & Yohannes, 2024). These findings underscore the importance of promoting students' interest as a strategy for improving learning outcomes.

Apart from cognitive and affective factors, learner

characteristics also influence students' academic achievement in Chemistry. Gender has continued to attract considerable attention in Chemistry education because of its potential influence on learning experiences and achievement. However, recent evidence suggests that gender alone is not a consistent predictor of academic achievement. Rather, differences in achievement are often mediated by students' attitudes, motivation, classroom participation and instructional strategies. For example, Pongsophon (2024) reported that students' attitudes significantly mediated achievement, whereas gender did not significantly moderate learning outcomes. Similarly, Iyiola and Ezech (2024) found that although gender influenced students' attitudes toward Chemistry, it did not significantly predict academic achievement. These findings suggest that creating equitable learning environments that encourage active participation and positive attitudes among both male and female students is more important than focusing solely on gender differences.

School location also remains an important contextual factor because it influences students' access to qualified teachers, laboratory facilities, instructional materials and other educational resources. Students in urban schools generally have greater access to these educational opportunities than those in rural schools, thereby facilitating better conceptual understanding and academic performance. Recent studies have shown that school location significantly influences students' achievement and perceptions of Chemistry concepts, although innovative instructional approaches have the potential to reduce location-based disparities and improve learning outcomes irrespective of school setting (Obikezie, Nwuba & Ibe).

Age is another learner characteristic associated with students' cognitive development, learning readiness and academic achievement in Chemistry. Differences in age may influence learners' reasoning ability, prior learning experiences, emotional maturity and capacity to comprehend abstract scientific concepts. Recent evidence indicates that age-related differences in achievement are more closely associated with developmental readiness and classroom experiences than with chronological age alone. Furthermore, students' maturity, grade level and accumulated learning experiences influence their attitudes toward Chemistry and their ability to understand complex concepts, thereby affecting academic achievement (Nwafor, Odukwe, Aghamelu & Muoneke, 2024). Collectively, contemporary literature suggests that students' academic achievement in Chemistry is shaped by the interaction of cognitive, affective and contextual variables rather than by any single factor. Perceived concept difficulty influences learners' confidence and conceptual understanding, students' interest enhances motivation and engagement, while gender, school location and age provide contextual conditions that may facilitate or constrain learning opportunities.

Empirical studies have continued to examine the factors

influencing students' academic achievement in Chemistry. Oladejo et al., (2023) investigated concept difficulty in secondary school Chemistry with emphasis on gender, school location and school type using a mixed-methods design involving 1,292 students from Nigeria and Ghana. Data were collected using the Difficult Concept in Chemistry Questionnaire (DCCQ) and interview guides. The findings revealed that school location and school type significantly influenced students' perception of difficult Chemistry concepts, whereas gender differences were minimal. The study further identified phobia for calculations and abstract concepts as major contributors to students' learning difficulties.

Similarly, Nja, Ukwetang, Orim, Neji, Edu, Ukah and Olofu (2022) investigated the influence of cultural resources and academic self-concept on the achievement of senior secondary school students in Chemistry in Calabar Municipality, Cross River State, Nigeria. The study adopted a quasi-experimental factorial research design. The population comprised Senior Secondary II Chemistry students in public secondary schools in Calabar Municipality, from which a sample of 90 students was selected. Two instruments were used for data collection: the Academic Self-concept Questionnaire (ASCQ) and the Chemistry Achievement Test (CAT). The instruments were validated by experts in Science Education, while the reliability coefficients were 0.80 for the ASCQ using Cronbach's alpha and 0.79 for the CAT using the Kuder-Richardson Formula 20 (KR-20). Data were analysed using dependent t-test and Analysis of Covariance (ANCOVA). The findings revealed that the use of cultural resources significantly improved students' academic self-concept and academic achievement in Chemistry. The study further established that students with higher academic self-concept achieved significantly better in Chemistry than those with lower academic self-concept.

In another study, Nnoli (2026) examined continuous assessment as a predictor of students' interest and academic achievement in Chemistry among secondary school students in Awka Education Zone, Anambra State, Nigeria. The study employed a correlational research design. The population consisted of 598 Senior Secondary II Chemistry students drawn from 64 public secondary schools, while a sample of 150 students was selected through a multistage sampling technique. Data were collected using students' continuous assessment records, a Students' Interest in Chemistry Scale and students' Chemistry achievement scores. The instruments were subjected to face and content validation by experts before administration, while reliability was established using appropriate internal consistency procedures as reported by the author. Pearson Product Moment Correlation and Multiple Regression were used for data analysis. The findings showed that continuous assessment significantly predicted students' interest and academic achievement in

Chemistry, indicating that regular classroom assessment enhances students' motivation, engagement and academic performance.

Furthermore, Obikezie et al., (2023) investigated the influence of school location and gender on the effectiveness of the Generative Learning Model on secondary school students' academic achievement in Chemistry in the Awka Education Zone of Anambra State, Nigeria. The study adopted a quasi-experimental research design guided by two research questions and two hypotheses. The population comprised 8,583 Senior Secondary School I (SS I) Chemistry students in 49 co-educational secondary schools, while a sample of 143 students (73 males and 70 females) was selected from four randomly selected schools using simple random sampling. The instrument used for data collection was the Chemistry Achievement Test (CAT), consisting of 50 multiple-choice items adapted from the West African Examinations Council (WAEC) past examination questions. The instrument was validated by experts in Science Education and Educational Foundations, while its reliability was established using the Kuder-Richardson Formula 20 (KR-20), which yielded a reliability coefficient of 0.87. Data were analysed using mean, standard deviation and Analysis of Covariance (ANCOVA) at the 0.05 level of significance. The findings revealed that students taught using the Generative Learning Model achieved significantly higher mean scores than their counterparts, with students in urban schools outperforming those in rural schools. The study also found that the instructional model was more beneficial to male students, indicating that school location and gender influenced students' academic achievement when the Generative Learning Model was employed.

More recently, Umahaba, Gambari, Thomas and Asaph (2026) examined the effect of the Process-Oriented Guided Inquiry Learning Strategy (POGILS) on students' academic performance in Organic Chemistry in Kwami Local Government Area of Gombe State, Nigeria. The study employed a pre-test, post-test, non-randomized, non-equivalent control group quasi-experimental design. The population comprised Senior Secondary School II students offering Chemistry in public secondary schools in the study area, from which a sample of 82 students (55 males and 27 females) was selected using a multistage sampling technique. Data were collected using the Organic Chemistry Performance Test (OCPT). The instrument was validated by experts in Chemistry Education, while its reliability was established using the split-half method, which yielded a reliability coefficient of 0.84. Data were analysed using Analysis of Covariance (ANCOVA) at the 0.05 level of significance. The findings revealed that students exposed to the Process-Oriented Guided Inquiry Learning Strategy performed significantly better in Organic Chemistry than those taught using the conventional lecture method. The

study further showed that gender did not significantly influence students' academic performance, and it recommended the adoption of learner-centred instructional strategies such as POGILS to improve students' understanding and achievement in difficult Chemistry concepts.

The reviewed studies have significantly contributed to understanding the determinants of students' academic achievement in Chemistry. However, most previous studies concentrated on isolated variables such as perceived concept difficulty, students' interest, gender, school location, instructional strategies or academic self-concept. Few studies have simultaneously examined the combined predictive influence of perceived concept difficulty, students' interest, gender, school location and age on students' academic achievement in Chemistry within a single analytical model. In addition, many existing studies adopted quasi-experimental or correlational designs that primarily evaluated instructional interventions rather than investigating the predictive relationships among learner characteristics.

Furthermore, there is limited empirical evidence focusing specifically on senior secondary school students in Cross River State, Nigeria, where contextual factors may differ from those reported in other regions. Consequently, this study sought to bridge these gaps by investigating the individual and combined influence of perceived concept difficulty, students' interest, gender, school location and age on academic achievement in Chemistry among senior secondary school students in Cross River State, Nigeria. This provides a more comprehensive understanding of how cognitive, affective and demographic variables interact to influence students' achievement in Chemistry.

Research question: To what extent do perceived concept difficulty, interest, gender, school location and age jointly influence students' academic achievement in Chemistry?

Statement of hypothesis: There is no significant joint influence of perceived concept difficulty, interest, gender, school location and age on students' academic achievement in Chemistry.

2. Methodology

This study adopted an *ex-post-facto* research design. The design was appropriate as it enabled the researcher to examine relationships among variables without manipulation. The study focused on Senior Secondary School III (SS III) Chemistry students, who were considered suitable due to their prior exposure to the relevant Chemistry concepts following the spiral curriculum structure.

The population comprised 8,702 students (4,418 males and 4,284 females) in 318 public co-educational secondary schools during the 2024/2025 academic session. A sample of 1,150 students was drawn from 162 schools using a multistage sampling technique involving stratified random sampling with proportionate allocation, where 50% of schools were selected from each Local Government Area (LGA) and further stratified by urban and rural locations, while students were also proportionately selected across age categories to ensure representativeness and generalizability.

Data were collected using three instruments: the Perceived Concept Difficulty in Chemistry Inventory (PCDCI), the Student Chemistry Interest Scale (SCIS), and the Chemistry Achievement Test (CAT). The PCDCI and SCIS were adapted from Christopher's (1977) Modified Vocational Interest Inventory Scale, while the CAT was developed by the researcher based on the SSS I–III Chemistry curriculum. Both the PCDCI and SCIS consisted of 60 items each, structured on four-point rating scales, while the CAT comprised 60 multiple-choice items with four options (A–D) aligned with West African Examinations Council standards to measure students' academic achievement in Chemistry.

The instruments were validated by experts in Chemistry Education and Measurement and Evaluation at the University of Cross River State, Calabar. A pilot test was conducted using 50 SS III Chemistry students from government secondary schools in Afaha Oku, Uyo Local Government Area of Akwa Ibom State. Reliability was determined using Cronbach's Alpha, yielding coefficients of 0.82 for PCDCI, 0.90 for SCIS, and 0.70 for CAT, indicating acceptable internal consistency. Permissions were obtained from school authorities before data collection, and instruments were administered with the assistance of trained research assistants. Data collected were analyzed using descriptive statistics, regression analysis and Analysis of Variance (ANOVA) with SPSS version 23.0, with all hypotheses tested at the 0.05 level of significance.

Table 1: Demographic description of study sample

Variable name	Category	N	%
Gender	Male	674	58.60
	Female	476	41.40
	Total	1150	100.00
Local	Urban	587	51.00
	Rural	563	49.00
	Total	1150	100.00
Age	Below 13 years	82	7.10
	13-15 years	289	25.10
	16-18 years	479	41.70
	19 years and above	300	26.10
	Total	1150	100.00
Chem. Concept difficulty	Difficult	143	12.40
	Moderately difficult	824	71.70
	Highly difficult	183	15.90
	Total	1150	100.00
Chem. Interest	Not interesting	149	13.00
	Moderately	794	69.00
	Highly interesting	207	18.00
	Total	1150	100.00

3. Results

The results in Table 1 show that 674 (58.6%) of the respondents were male and 476 (41.4%) were female, indicating higher male participation in Chemistry, likely reflecting existing enrollment patterns influenced by societal expectations and career inclinations, and the notable proportion of females suggests improving gender inclusion. In terms of location, 587 (51.0%) of the students were from urban schools and 563 (49.0%) from rural schools, showing a balanced distribution, with the slight urban majority possibly due to better access to educational resources such as qualified teachers, laboratories and instructional materials.

The age distribution indicates that most students, 479 (41.7%), were within 16–18 years, consistent with the expected SS III age range, while those aged 19 years and above (26.1%) may reflect late entry or repetition, and the small proportion below 13 years (7.1%) suggests early progression; these variations can influence cognitive development and learning experiences. Regarding perceived concept difficulty, 824 (71.7%) of students rated Chemistry concepts as moderately difficult, while 183 (15.9%) and 143 (12.4%) perceived them as highly difficult and difficult respectively; similarly,

794 (69.0%) found Chemistry moderately interesting, compared to 207 (18.0%) who found it highly interesting and 149 (13.0%) who found it not interesting. This pattern indicates that most students experience moderate challenge and interest, likely due to the abstract nature of Chemistry, limited practical exposure, and teaching approaches, suggesting that improved instructional strategies and learning environments could enhance students' interest and academic achievement in the subject.

3.1. Hypothesis Testing

Hypothesis: *There is no significant joint influence of perceived concept difficulty, interest, gender, school location and age on students' academic achievement in Chemistry.*

To test this hypothesis, 5-way analysis of variance was applied with perceived concept difficulty, interest, gender, school location and age as the factors and students' academic achievement in Chemistry as dependent variable. The F-ratio test was used to test for the significance of the main and interaction effect and Fishers' Least Significant Difference (LSD) test was applied as *post hoc* test. The results was as presented in Table 2.

Table 2: Multi ANOVA of Chemistry Achievement by Perceived Concept Difficulty, Interest, Gender, School location and Age

Source of variation	Sum of squares	df	Mean square	F-ratio	p-value
Corrected Model	284.287	114	24.924	.937	.664
Intercept	2551463.880	1	2551463.880	95954.928*	.000
Gender	4.208	1	4.208	.158	.691
School location	6.118	1	6.118	.230	.632
Age	174.494	3	58.165	2.187	.088
Chem. concept difficulty	19.400	2	9.700	.365	.694
Chemistry interest	79.557	2	39.779	1.496	.225
Gender and School location	51.816	1	51.816	1.949	.163
Gender and Age	49.986	3	16.662	.627	.598
Gender and Chem. concept difficulty	25.721	2	12.860	.484	.617
Gender and Chem. Interest	32.941	2	16.470	.619	.538
School location and Age	38.476	3	12.825	.482	.695
School location and Chem. concept difficulty	3.948	2	1.974	.074	.928
School location and Chem. Interest	42.468	2	21.234	.799	.450
Age and Chem. concept difficulty	239.511	6	39.919	1.501	.174
Age and Chem. Interest	70.697	6	11.783	.443	.850
Chem. Concept difficulty and Chem. Interest	33.610	3	11.203	.421	.738
Gender, Sch. location and Age	238.236	3	79.412	2.987*	.030
Gender, Sch. location and Chem. concept difficulty	90.858	2	45.429	1.708	.182
Gender, Sch. location and Chem. Interest	67.179	2	33.589	1.263	.283
Gender, Age and Chem. concept difficulty	170.863	6	28.477	1.071	.378
Gender, Age and Chem. Interest	90.481	6	15.080	.567	.757
Gender, Chem. concept difficulty and Chem. Interest	57.972	3	19.324	.727	.536
Sch. location, Age and Chem. concept difficulty	134.093	6	22.349	.840	.539
Sch. location, Age and Chem. Interest	171.227	6	28.538	1.073	.377
Sch. location, Chem. concept difficulty and Chem. Interest	57.630	3	19.210	.722	.539
Age, Chem. concept difficulty and Chem. Interest	163.210	8	20.401	.767	.632
Gender, Sch. location, Age and Chem. concept difficulty	251.483	5	50.297	1.892	.093
Gender, Sch. location, Age and Chem. Interest	88.869	5	17.774	.668	.647
Gender, Sch. location, Chem. concept difficulty and Chem. Interest	162.936	3	54.312	2.043	.106
Gender, Age, Chem. concept difficulty and Chem. Interest	37.727	5	7.545	.284	.922
Sch. location, Age, Chem. concept difficulty and Chem. Interest	199.072	6	33.179	1.248	.279
Gender, Sch. location, Age, Chem. concept difficulty and Chem. Interest	15.996	3	5.332	.201	.896
Error	27520.891	1035	26.590		
Total	13691140.44	1150			
Corrected Total	30362.178	1149			

*Significant at .05 level $p < .05$

The results presented in Table 2 indicate that the overall corrected model was not statistically significant, $F(114, 1035) = 0.937$, $p = .664$, implying that the combined effects of perceived concept difficulty, interest, gender, school location and age, together with their interaction effects, did not significantly explain variations in students' academic achievement in Chemistry. Consequently, the null hypothesis of no significant joint influence was generally retained.

The results further revealed that the main effects of gender ($F = 0.158$, $p = .691$), school location ($F = 0.230$, $p = .632$), age ($F = 2.187$, $p = .088$), perceived concept

difficulty ($F = 0.365$, $p = .694$) and Chemistry interest ($F = 1.496$, $p = .225$) were all not statistically significant at the 0.05 level. Similarly, all two-way, three-way and four-way interaction effects were not statistically significant ($p > .05$), except the interaction among gender, school location and age, which was statistically significant ($F = 2.987$, $p = .030$).

The significant three-way interaction indicates that the influence of gender on students' academic achievement in Chemistry varied according to students' age and school location. Based on this result, the null hypothesis was partially rejected for the interaction of gender, school

location and age but retained for all other main and interaction effects. This suggests that students' academic achievement in Chemistry was influenced not by any single

factor independently but by the combined interaction of gender, school location and age

Table 3: Multiple Pairwise LSD Comparison of Chemistry Achievement by Perceived Concept Difficulty, Interest, Gender, School location and age

Age	Age	Mean Difference	Std. Error	p-values
Below 13 years	13-15 years	-.033	.645	.959
	16-18 years	-.227	.616	.713
	19 years and above	.385	.643	.550
13-15 years	below 13 years	.033	.645	.959
	16-18 years	-.194	.384	.613
	19 years and above	.418	.425	.326
16-18 years	below 13 years	.227	.616	.713
	13-15 years	.194	.384	.613
	19 years and above	.612	.380	.107
19 years and above	below 13 years	-.385	.643	.550
	13-15 years	-.418	.425	.326
	16-18 years	-.612	.380	.107
Not difficult	Moderately difficult	.416	.467	.373
	Highly difficult	-.495	.576	.390
Moderately difficult	Not difficult	-.416	.467	.373
	Highly difficult	-.911*	.421	.031
Highly difficult	Not difficult	.495	.576	.390
	Moderately difficult	.911	.421	.031
Not interesting	Moderately interesting	-1.555*	.460	.001
	Highly interesting	-2.482*	.554	.000
Moderately interesting	Not interesting	1.555*	.460	.001
	Highly interesting	-.926*	.402	.022
Highly interesting	Not interesting	2.482*	.554	.000
	Moderately interesting	.926*	.402	.022

*Significant at .05 level $p < .05$

**Values along diagonal are group means, above it is mean differences and above it is corresponding p-values

The results in Table 3 show that age did not significantly influence any of the paired comparisons ($p > .05$), indicating that students across different age groups did not differ meaningfully in perceived concept difficulty, interest, or academic achievement in Chemistry, likely because all respondents were SS III students exposed to similar curriculum content and learning conditions, thereby minimizing age-related effects despite differences in maturity.

In terms of perceived concept difficulty, only the difference between students who rated Chemistry as moderately difficult and those who rated it as highly difficult was significant ($MD = .911$, $p = .031$), suggesting that students who perceive the subject as highly difficult experience greater learning challenges such as anxiety, cognitive overload and reduced engagement, which negatively impact achievement, whereas those who see it as moderately difficult are better able to cope and perform.

For interest in Chemistry, all paired comparisons were significant ($.926 \leq MD \leq 2.482$; $p \leq .05$), indicating that variations in interest levels consistently produced significant differences in academic achievement; this highlights interest

as the most influential factor, as students with higher interest are more motivated, engaged and persistent in learning, while those with low interest tend to disengage, thereby justifying the conclusion that interest plays a central role and may even mediate the effects of perceived difficulty and other variables on students' academic achievement in Chemistry.

4. Discussion

The findings of this study revealed that perceived concept difficulty, students' interest, gender, school location and age did not exert significant independent influences on students' academic achievement in Chemistry. Although students generally perceived Chemistry concepts as moderately difficult and expressed moderate interest in the subject, these variables did not independently predict achievement. This suggests that students' academic performance may be influenced by a broader combination of cognitive, instructional and contextual factors beyond their individual perceptions or demographic characteristics. The non-significant effect of perceived concept difficulty implies

that students can overcome challenging concepts when supported by effective instructional practices, adequate learning resources and collaborative learning opportunities. This finding is consistent with the work of Wilkes et al., (2024), who reported that students' perceptions of conceptual challenge do not necessarily translate into poor academic performance when appropriate pedagogical support is available. However, the finding differs from that of Oladejo et al., (2023), who found that students' perceived difficulty in Chemistry concepts was associated with lower learning outcomes, suggesting that the relationship between perceived difficulty and achievement may depend on the learning environment and instructional context.

The study further revealed that students' interest, gender, school location and age did not significantly influence academic achievement when considered separately. This finding indicates that demographic characteristics alone may not be sufficient to explain variations in students' performance in Chemistry, particularly where students are exposed to similar curricula, assessment standards and instructional experiences. The result supports recent studies by Obikezie et al., (2023), and Umahaba et al., (2026), which reported that gender and school location did not significantly moderate students' achievement when learner-centred instructional approaches were implemented. Similarly, the absence of a significant age effect suggests that differences in chronological age among Senior Secondary III students may have limited influence on achievement because learners are generally at comparable stages of cognitive development and academic exposure. Nonetheless, the significant pairwise differences observed for students' interest indicate that higher levels of interest were associated with better academic performance, emphasizing the practical importance of sustaining students' motivation and engagement even where the overall main effect was not statistically significant.

A notable finding of the study was the significant interaction among gender, school location and age, indicating that these variables jointly influenced students' academic achievement in Chemistry. This suggests that the effect of one demographic variable depends on the levels of the others, highlighting the complexity of students' learning experiences. For example, differences associated with gender may become more evident within particular age groups or school locations because of variations in access to instructional resources, learning opportunities and socio-cultural conditions. This finding reinforces contemporary perspectives that academic achievement results from the interaction of multiple learner and contextual factors rather than isolated variables. It also supports the ecological view of learning, which emphasizes that educational outcomes are shaped by the combined influence of personal and environmental characteristics. Consequently, interventions aimed at improving students' achievement in Chemistry should adopt a holistic approach by strengthening instructional quality, promoting students' interest and addressing contextual disparities across schools while recognizing the interaction among demographic factors.

5. Conclusion

The findings of this study demonstrate that perceived

concept difficulty, students' interest, gender, school location and age did not independently predict students' academic achievement in Chemistry among Senior Secondary School III students in Cross River State, Nigeria. Although the respondents generally perceived Chemistry concepts as moderately difficult and expressed moderate interest in the subject, these factors were not significant independent determinants of achievement. Similarly, gender, school location and age did not produce significant main effects on students' academic performance. However, the study established a significant interaction among gender, school location and age, indicating that students' achievement in Chemistry is better explained by the combined influence of these demographic variables than by their individual effects.

The study therefore concludes that academic achievement in Chemistry is a multidimensional phenomenon influenced by the interaction of learner and contextual characteristics rather than by isolated cognitive, affective or demographic factors. While perceived concept difficulty and students' interest alone may not be sufficient to explain variations in achievement, their interplay with demographic and environmental conditions contributes to students' learning outcomes. Consequently, efforts to improve achievement in Chemistry should adopt an integrated approach that strengthens instructional practices, enhances supportive learning environments and addresses contextual differences across schools while recognizing the interactive effects of students' demographic characteristics.

Recommendations

Based on the findings and conclusion of the study, the following recommendations were made:

1. Teachers should adopt engaging, real-life and learner-centered teaching strategies to sustain students' interest in Chemistry, as it strongly influences academic achievement.
2. Schools should support students in handling difficult concepts through guided instruction and collaborative learning to reduce negative effects of perceived difficulty.
3. Policymakers should improve resources and learning conditions across schools to address the combined influence of gender, age and location on achievement.
4. Curriculum planners should present challenging concepts in simplified, relatable ways that enhance understanding and maintain students' interest.

Abbreviations

CAT	Chemistry Achievement Test
PCDCI	Perceived Concept Difficulty in Chemistry Inventory
ANOVA	Analysis of Variance
POGILS	Process-Oriented Guided Inquiry Learning Strategy
ASCQ	Academic Self-concept Questionnaire Organic
OCPT	Chemistry Performance Test
SPSS	Statistical Package for the Social Science
WAEC	West African Examinations Council

LGA	Local Government Area
DCCQ	Difficult Concept in Chemistry Questionnaire
OCPT	Organic Chemistry Performance Test
SCIS	Student Chemistry Interest Scale

Author Contributions

Ekpo Bassey Ekpo: Conceptualization, Investigation, Validation, writing –Review & Editing, Project Administration, Methodology, Data Curation, Investigation, Formal Analysis, Writing - original draft,

Conflicts of Interest

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