



**LABORATORY FACILITIES AS DETERMINANTS FOR SECONDARY SCHOOL STUDENT'S INTEREST IN CHEMISTRY EDUCATION: A CASE STUDY OF SELECTED SECONDARY SCHOOLS IN ODEDA LOCAL GOVERNMENT AREA OF OGUN STATE, NIGERIA**

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### ABSTRACT

*The study examined the laboratory facilities as determinants for secondary school students' interest in chemistry education: a case study of selected secondary schools in Odeda Local Government Area of Ogun State, Nigeria. A total of 120 students were selected from two secondary schools in Odeda local government area of Ogun State, Nigeria. Descriptive and inferential statistics such as percentages, frequency counts, mean, standard deviation and t-test analysis were used for the analysis. Results showed that the mean age of the students was 15.73 years, and 51.7% were female, 85.0% were from SS2 and 69.2% from public secondary school. Results show that few laboratory facilities are available for chemistry education in the selected secondary schools ( $\bar{x} = 1.54$ ). In addition, all the students indicated that laboratory facilities were enough in their secondary school ( $\bar{x} = 3.70$ ) and they were all interested in chemistry with the level of available laboratory facilities in their school ( $\bar{x} = 3.98$ ). The result obtained shows that there is significant relationship between the respondents' gender, grade/class and age ( $p < 0.05$ ) respectively. Findings shows no significant relationship ( $r = 0.146$ ,  $P > 0.05$ ) between available laboratory facilities and the interest of secondary school students in chemistry. Lastly, result shows no significant difference ( $F = 3.318$ ,  $t = -1.496$ ;  $p = 0.071$ ) in students' interest in chemistry education between public and private secondary schools selected. The study concluded that laboratory facilities are not a determining factor for students' interest in chemistry education in Faith Heritage College, Abeokuta and Nawair-Ud-Deen Grammar School, Obantoko, Abeokuta, Ogun state, Nigeria. It is then recommended that the teachers and educators should focus on identifying and addressing other factors that influence students' interest in chemistry, such as attitude, motivation, and learning preferences and further research should be conducted to investigate the factors that promote student interest in chemistry in the study area.*

Keywords: Interest, Laboratory Facilities, Secondary School Students and Chemistry Education.

### INTRODUCTION

Chemistry is a central science that bridges various scientific disciplines, including biology, physics and other science related subjects. It plays a critical role in understanding the material world, from the composition and properties of substances to the changes they undergo during chemical reactions (Usselman, and Roche, 2024). Given its significance, a robust chemistry education is fundamental in preparing students for careers in Science, Technology, Engineering, and



Mathematics (STEM), which are crucial for national development and global competitiveness. Chemistry education imparts essential knowledge and skills that enable students to understand natural phenomena, develop critical thinking abilities, and solve complex problems. According to Nsabayeze *et al.*, (2023), effective chemistry education involves both theoretical instruction and practical laboratory experiences. Laboratory work is particularly important because it allows students to observe chemical principles in action, conduct experiments, and engage in scientific inquiry. These hands-on experiences are vital for deepening students' understanding and fostering a passion for the subject. As opined by Sroczyński (2023) that students that use laboratory facilities have a better comprehension of the physical sciences.

Despite the acknowledged importance of practical laboratory experiences, many schools in Nigeria face significant challenges in providing adequate laboratory resources and facilities. Lawrence (2024) highlighted that many Nigerian schools are ill-equipped, with laboratories often lacking essential equipment, chemicals, and safety materials. This inadequacy leads to a theoretical approach to teaching chemistry, with minimal practical experimentation (Lawrence, 2024). As a result, students may find chemistry abstract and unengaging, which can lead to decreased interest and poor academic performance. The problem is further compounded by socio-economic disparities, leading to significant variations in the quality of education across different regions and schools in Nigeria (Adewusi *et al.*, 2023). This issue is more pronounced in public schools and rural areas, where funding and resource allocation are limited. As a result, students in these schools are deprived of the full benefits of a comprehensive chemistry education due to unavailable laboratory facilities. This affects students' academic performance and their interest in chemistry and other science subjects due to a lack of laboratory facilities (Maarseveen, 2020). This assertion implies that the unavailability of laboratory resources often results in a lack of interest and motivation among students, who may find it difficult to grasp complex chemical concepts without practical demonstrations.

According to Genie (2024), laboratory experiences are essential for developing scientific literacy and competence. They enable students to connect theoretical knowledge with real-world applications, thereby enhancing their understanding and retention of scientific concepts. In the context of Nigerian schools, the scarcity of laboratory resources not only diminishes the quality of chemistry education but also reduces students' enthusiasm, interest and engagement, potentially deterring them from pursuing further studies and careers in science. Therefore, this study aims to fill this gap by assessing the laboratory facilities as determinants for secondary school students' interest in chemistry education: a case study of selected secondary schools in Odeda Local Government Area of Ogun State, Nigeria. The specific objectives of the study describe the personal characteristics of the students, identify the available laboratory facilities used by the students for chemistry, examine if the laboratory facilities are enough for all the secondary school students, and determine the interest of secondary school students in chemistry with the level of available laboratory facilities in their school. It is hypothesized that available laboratory facilities are not significantly related with the interest of secondary school students in chemistry and there is no significant difference between public and private school students' interest in chemistry education based on the level of laboratory facilities in the study area.

## **MATERIALS AND METHODS**



This study was carried out in Ogun state. The Secondary Schools used for this study are Faith Heritage College, Abeokuta and Nawair-Ud-Deen Grammar School, Obantoko, Abeokuta, Ogun state, Nigeria.

### **Sampling procedures and size**

A multistage sampling procedure was used for selecting respondents for this study. Out of the 20 local government in Ogun state, Nigeria, a simple random sampling technique was used to select Odeda local government area. The second stage involves the selection of two (2) secondary schools namely; Faith Heritage College and Nawair-Ud-Deen Grammar School, Obantoko, Abeokuta. A simple random sampling was used to select thirty-two percent (32%) of the total students from SS1 and SS2 students and this gives 83 students from Nawair-Ud-Deen Grammar School, Obantoko and the entire 37 students from SS1 and SS2 class from Faith Heritage College, Abeokuta was used due to their size/population. A total of 150 questionnaires were distributed and 120 were retrieved and found usable. This signified a response rate of 80.0%.

Therefore, since over 80.0% response rate was achieved, non-response error is not a threat to the external validity of the study findings (Lindner and Wingenbach 2002). A structured questionnaire was used to elicit information from the respondents after it was content and face-validated. Also, a Cronbach-alpha test of internal consistency was conducted with reliability coefficients of 0.76. The frequency of available laboratory facilities was measured on a two (2) point rating scale of available (2) and not available (1) on a total of 15 items. Fifteen items relating to laboratory facilities were adopted from the works of (Pareek, 2022) to ascertain the available laboratory facilities for chemistry education in the study area. Are laboratory facilities enough for all the students in your secondary school were measured with a Likert-type scale of strongly agree (5), agree (4), undecided (3), disagree (2) and strongly disagree (1) on a total of (5) items. Ten items relating to the interest of secondary school students in chemistry with the level of available laboratory facilities in their school were adapted from the works of Schiefele cited in Knekta *et al.*, (2020) on the Students Interest Questionnaire (SIQ), to assess the interest of secondary school students in chemistry with the level of available laboratory facilities in their school. Sample items are; I am more interested in chemistry when practical experiments are included in the lessons, I feel confident in my understanding of chemistry concepts with hands-on laboratory experience, and I enjoy chemistry more when I can perform experiments myself. Responses on all the scale items were ordered on a five-point rating scale of Very High Interest (V.H.I). (5), High Interest (H.I) (4), Moderate Interest (M.I) (3), Low Interest (L.I) (2), and Very Low Interest (V.L.I) (1).

### **Data Analysis**

The personal characteristics of students were measured; age was measured at interval levels; gender and school type were all measured at a nominal level while grade/class was measured at an ordinal level. The study is correctional in design, objectives were analyzed using descriptive statistics such as frequency counts, percentages and mean. For Table 2, Each level is assigned a number from 2-1(Available =2, not available = 1). This was used to answer questions in Table 2. For Table 3, each level was assigned a number ranging from 5-1(Strongly Agree/ Very High Interest =5, Agree/ High Interest 4, Undecided/ Moderate Interest =3, Disagree/ Low Interest =2 and Strongly Disagree/ Very Low Interest= 1). This was used to answer all the questions in Tables



3 and 4 while inferential statistics such as Pearson's Product Moment Correlation coefficient (PPMC), Chi-square, and T-Test was used to test the hypotheses of this study.

### Students' personal characteristics

The result in Table 1 revealed the mean age and standard deviation as 15.73years $\pm$ 1.561 respectively with 45.0% of the students within the age bracket of 16 and 18years. This means that a larger percentage of the students within the study location were developing and exploring their interests and career paths. These findings imply that students in Faith Heritage College, Abeokuta and Nawair-Ud-Deen Grammar School, Obantoko, Abeokuta, Ogun state, Nigeria are teenagers, to this end, it is expected that they are preparing for post-secondary school education or entering the workforce. This claim corroborates the earlier findings of Organisation for Economic Co-operation and Development (OECD), (2019) that most of the teenagers have to make important decisions relevant to their working lives later on, such as what field of study or type of education they will pursue. A good number (51.7%) of the students were female, 85.0 percent of them were from SS2 and 69.2percent were from public secondary school. This implies that most of the students sampled were from Nawair-Ud-Deen Grammar School, Obantoko, Abeokuta, Ogun state, Nigeria.

**Table 1: Personal Characteristics of students (n=120)**

Variables	Frequency	Percentage	Mean	SD
Age				
<b>12-15</b>	63	52.5		
<b>16-18</b>	54	45.0	15.73	1.561
<b>18 and above</b>	3	2.5		
Gender				
<b>Male</b>	58	48.3		
<b>Female</b>	62	51.7		
Grade/Class				
<b>SS1</b>	18	15		
<b>SS2</b>	102	85		
School Type				
<b>Public</b>	83	69.2		
<b>Private</b>	37	30.8		

Source: Field Survey, (2024); standard deviation (sd)

### The available laboratory facilities for chemistry education in the study area

Results in Table 2 below show the distribution of respondents according to their response on the available laboratory facilities for Chemistry education in their school. The results showed that all the respondents of about 120(100%) stated that spectrophotometers, electrochemical cells, distillation apparatus, and centrifuge is not available in their school respectively, larger percentage



of about 117(97.5%) of the respondents claimed that microscopes and volumetric flask are available respectively in their school, majority of about 75(62.5%) of the respondents affirmed that ph-meter is available. All the students of about 120(100%) reported that thermometer, testtubes, gas-burner, and boiling tube is available in their school respectively, majority of about 116(96.7%) claimed that granulated cylinder is available in their school, majority of the students of about 104(86.7%) said safety goggles is not available in their school, majority of about 79(65.8%) of the students stated that capillary tube is not available and 76(63.3%) of the students claimed that tripod stand is not available. This showed that few laboratory facilities are available in secondary schools in Faith Heritage College, Abeokuta and Nawair-Ud-Deen Grammar School, Obantoko, Abeokuta, Ogun state, Nigeria which indicated that most laboratory facilities are not available in secondary schools in the study area for teaching chemistry. The implication of these findings is that some laboratory facilities are available in the study area and hence may enhance their interest in chemistry education. Similarly, Etiubon (2020) observes that the laboratory facilities boost educational effectiveness and productivity, enhancing human capacity, knowledge, and skills for economic growth and development.

**Table2: The available laboratory facilities for chemistry education in your school (n=120).**

S/N	Laboratory Facilities	Available N (%)	Not Available N (%)
1	Spectrophotometers	-	120(100.0)
2	Microscopes	117(97.5)	3(2.5)
3	Electrochemical Cells	-	120(100.0)
4	Distillation Apparatus	-	120(100.0)
5	pH Meters	75(62.5)	45(37.5)
6	Thermometers	120(100.0)	-
7	Granulated Cylinders	116(96.7)	4(3.3)
8	Test Tubes	120(100.0)	-
9	Safety Goggles	16(13.3)	104(86.7)
10	Centrifuge	-	120(100.0)
11	Volumetric Flask	117(97.5)	3(2.5)



12	Gas burner	120(100.0)	-
13	Boiling tube	120(100.0)	-
14	Capillary tube	41(34.2)	79(65.8)
15	Tripod Stand	44(36.7)	76(63.3)

Source: Field Survey, (2024); A: Available, NA: Not Available.

### Are laboratory facilities enough for all the students in your secondary school.

Findings in Table 3 below shows the distribution of respondents according to their response on if laboratory facilities are enough for all the students in their secondary school. The results revealed that majority of about 49(40.8%) strongly agree that the available laboratory equipment is adequate for conducting all required experiments. Larger percentage of the students of about 41(34.2%) indicated that all students have sufficient access to laboratory resources during chemistry classes. Majority of about 34(28.3%) of the students strongly agree that safety equipment is provided for all students and protocols are adequately provided and followed in the laboratory. Majority of the students of about 51(42.5%) agree that the availability of chemicals and reagents is sufficient for all students during planned experiments and larger percentage of the students of about 42(35.0%) strongly agree that laboratory resources are distributed equitably among all students during practical sessions. This showed that laboratory facilities are enough for all students in Faith Heritage College, Abeokuta and Nawair-Ud-Deen Grammar School, Obantoko, Abeokuta, Ogun state, Nigeria. The findings imply that all students learn chemistry by using laboratory facilities during their chemistry practical. This is in line with the studies of Afyusisye & Gakuba, (2022) and Shana & Abulibdeh, (2020) who stated that hands-on learning (Learning by doing) increases students' motivation, interest, and comprehension of chemistry concepts.

**Table 3: Are laboratory facilities enough for all the students in your secondary school (n=120)**

S/N	ITEMS	S.A N (%)	A N (%)	U N (%)	D N (%)	S.D N (%)	Mean	S.D	Decision
1	The available laboratory equipment is adequate for conducting	49(40.8)	43(35.8)	18(15.0)	5(4.2)	5(4.2)	4.05	1.052	Agree



	all required experiments.								
2	All students have sufficient access to laboratory resources during chemistry classes.	39(32.5)	41(34.2)	20(16.7)	14(11.7)	6(5.0)	3.78	1.170	Agree
3	Safety equipment is provided for all students and protocols are adequately provided and followed in the laboratory.	34(28.3)	33(27.5)	26(21.7)	11(9.2)	16(13.3)	3.48	1.347	Agree
4	The availability of chemicals and reagents is sufficient for all students during planned experiments.	28(23.3)	51(42.5)	23(19.2)	8(6.7)	10(8.3)	3.66	1.156	Agree
5	Laboratory resources are distributed equitably among all students	42(35.0)	32(26.7)	19(15.8)	5(4.2)	22(18.3)	3.56	1.466	Agree



during  
practical  
sessions.

Source: Field Survey, (2024); SA: Strongly Agree, A: Agree, U: Undecided, D: Disagree, SD: Strongly Disagree

### **The interest of secondary school students in chemistry with the level of available laboratory facilities in their school.**

Data in Table 4 below show the distribution of respondents according to their interest in chemistry with the level of available laboratory facilities in their school. The results revealed that majority of about 77(64.2%) had very high interest in chemistry when practical experiments are included in the lessons. Larger percentage of the students sampled of about 47(39.2%) claimed that they had high interest in chemistry despite the limited access to laboratory resources which makes chemistry less interesting and engaging in the study area. Majority of the students of about 43(36.1%) stated that with the level of available laboratory facilities in their school they had interest and they feel confident in their understanding of chemistry concepts with hands-on laboratory experience. Majority of about 61(50.8%) of the students said they had very high interest in chemistry due to the availability of laboratory resources which influences their motivation to learn chemistry. A good number of the students of about 60(50.0%) reported that they had very high interest and enjoy chemistry more when they can perform experiments their self. Larger percentage of about 40(33.3%) claimed that they had very high interest in Chemistry despite the lack of laboratory resources which affects their performance in chemistry in the study area. Majority of the students of about 69(57.5%) reported that they had very high interest in chemistry and believe having better laboratory resources would improve their understanding of chemistry. About 41(34.2%) of the students indicated that they had very high interest in chemistry and are likely to pursue further studies in chemistry if they have more practical experience. Majority of the students of about 44(36.7%) reported that they had very high interest in chemistry because the quality of laboratory facilities impacts their overall interest in science subjects and lastly, about 40(33.3%) of the students reported that despite their very high interest in chemistry, they find it difficult to relate theory to practice in chemistry due to inadequate laboratory resources in their school. The implication of this result showed that all the students in Faith Heritage College, Abeokuta and Nawair-Ud-Deen Grammar School, Obantoko, Abeokuta, Ogun state, Nigeria are interested in chemistry with the level of available laboratory facilities in their school. Negating the claim of Esiobu (2005) that noted in his study that students in secondary schools are not very much interested in science subjects. However, Afyusisye & Gakuba, (2022) corroborated with this study, who asserted that availability of laboratory facilities promotes active participation, and engagement in learning, and it draws students' attention to the lesson.

**Table 4: The interest of secondary school students in chemistry with the level of available laboratory facilities in their school (n=120)**

S/N	ITEMS	V.H.I	H.I	M.I	L.I	V.L.I
		N (%)	N (%)	N (%)	N (%)	N (%)
1	I am more interested in chemistry when practical experiments are included in the lessons.	77(64.2)	35(29.2)	5(4.2)	-	<b>3(2.5)</b>
2	Limited access to laboratory resources makes chemistry less interesting and engaging.	44(36.7)	47(39.2)	9(7.5)	12(10.0)	<b>8(6.7)</b>
3	I feel confident in my understanding of chemistry concepts with hands-on laboratory experience.	41(34.5)	43(36.1)	21(17.6)	5(4.2)	<b>9(7.5)</b>
4	The availability of laboratory resources influences my motivation to learn chemistry.	61(50.8)	29(24.2)	17(14.2)	7(5.8)	<b>6(5.0)</b>
5	I enjoy chemistry more when I can perform experiments myself.	60(50.0)	32(26.7)	12(10.0)	7(5.8)	<b>9(7.5)</b>
6	The lack of laboratory resources affects my performance in chemistry.	40(33.3)	34(28.3)	22(18.3)	10(8.3)	<b>14(11.7)</b>
7	I believe having better laboratory resources would improve my understanding of chemistry.	69(57.5)	27(22.5)	14(11.7)	4(3.3)	<b>6(5.0)</b>
8	I am likely to pursue further studies in chemistry if I have more practical experience.	41(34.2)	42(35.0)	24(20.0)	4(3.3)	<b>9(7.5)</b>
9	The quality of laboratory facilities impacts my overall interest in science subjects.	44(36.7)	42(35.0)	18(15.0)	10(8.3)	<b>6(5.0)</b>



10	I find it difficult to relate theory to practice in chemistry due to inadequate laboratory resources.	40(33.3)	42(35.0)	19(15.8)	7(5.8)	<b>12(10.0)</b>
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Source: Field Survey, (2024); (Very Low Interest = V.L.I), Low Interest = (L.I), Moderate Interest = (M.I), High Interest = (H.I), Very High Interest = (V.H.I).

### **Test of association between respondents' personal characteristics of respondents and the available laboratory facilities in the study area.**

The result of this hypothesis “there is no significant association between respondents' personal characteristics and the available laboratory facilities” was tested using Chi-square, the socio economic considered were gender, grade/class, school type and age. The significance of the relationship was determined at 0.05 levels, the result obtained shows that there is significant relationship between the respondents' gender, grade/class and age (p-value = 0.000, 0.000, 0.000,  $p < 0.05$ ) respectively while the school type is not significant (p-value = 0.326,  $p > 0.05$ ). Therefore, there is no association between available laboratory facilities and school type.

**Table 5: Chi-square showing association between available laboratory facilities and respondents personal characteristics.**

Variables	Chi-square test	DF	P-Value	Decision
<b>Gender</b>	0.965	<b>1</b>	<b>0.001</b>	<b>S</b>
<b>Grade/Class</b>	35.034	<b>1</b>	<b>0.001</b>	<b>S</b>
<b>School Type</b>	104.701	<b>1</b>	<b>0.326</b>	<b>NS</b>

  

Variables	Correlation Value	P-Value	Decision
<b>Age</b>	-0.452	<b>0.001</b>	<b>S</b>

Note: \*\*\*= (P<0.01) Significant at 1 %, \*\*= (p<0.05) Significant at 5 %  
Source: Field survey, (2024).

### **Test of relationship between available laboratory facilities in the study area and the interest of secondary school students in chemistry with the level of available laboratory facilities in the study area.**

Findings in Table 6 present the result of the hypothesis “there is no significant relationship between available laboratory facilities in the study area and the interest of secondary school students in

chemistry with the level of available laboratory facilities in the study area;” was tested using Pearson Product-Moment Correlation Coefficient. Findings shows that there is no significant relationship ( $r = 0.146$ ,  $P > 0.05$ ) between available laboratory facilities in the study area and the interest of secondary school students in chemistry with the level of available laboratory facilities in the study area. This finding therefore indicates that respondents pointed out that laboratory facilities does not instil their interest in chemistry in the study area. This result implies that other factors may be more influential in shaping students' interest in chemistry in the study area, and highlights the need for further investigation into the factors that promote student interest in chemistry in the study area. According to Musengimana *et al.*, (2021), attitude of students toward learning of chemistry is critical factor that contribute to their interest in chemistry. This also aligns with the findings of Akram *et al.*, (2017) that factors such as personal traits and choices, role of teacher, and professional scope of chemistry enhance students' interest in chemistry. The hypothesis therefore will be accepted while the alternative will be rejected that “there is no significant relationship between available laboratory facilities in the study area and the interest of secondary school students in chemistry with the level of available laboratory facilities in the study area.

**Table 6: Showing test of relationship between available laboratory facilities in the study area and the interest of secondary school students in chemistry with the level of available laboratory facilities in the study area.**

Variable	Correlation Value	P-Value	Decision
<b>Relationship between available laboratory facilities in the study area and the interest of secondary school students in chemistry with the level of available laboratory facilities in the study area.</b>	<b>0.146</b>	<b>0.074</b>	<b>NS</b>

Source: Field survey, (2024); \*S = Significant difference at  $P > 0.05$  level of significance.

#### **Test of significant difference between students' interest in chemistry education based on the level of laboratory facilities available in the study area.**

Findings in Table 7 present the result of the hypothesis “there is no significant differences between students' interest in chemistry education based on the level of laboratory facilities available in the study areas” was tested using T-Test. Findings shows that there is no significant difference ( $F = 3.318$ ,  $P > 0.05$ ). Therefore, no significant difference was found in students' interest in chemistry education between public and private secondary schools in the study area, indicating that laboratory facilities are not a determining factor for students' interest in chemistry education in the study area. According to Amoako *et al.*, (2022) a number of variables are responsible for student interest in chemistry such as prior education (Hanus & Fox, 2015), parents' education, family income, self-motivation, age of student, learning preferences (Sieg & Wang, 2018). In tandem to



this, Joel *et al.*, (2022) concluded that student attitude is a critical factor that determines students' interest and engagement in chemistry (Kahu and Nelson, 2018).

**Table 7: Showing T-Test of analysis on the responses of public and private students on their interest in chemistry education based on the level of laboratory facilities available in their school.**

\*S = Significant difference at  $P > 0.05$  level of significance.

Laboratory facilities	School Type	N	Mean	S.D	DF	F	t-cal.	P-cal.	Decision
Interest of students in chemistry with level of laboratory facilities	<b>Public</b>	<b>83</b>	<b>39.22</b>	<b>6.708</b>	<b>118</b>	<b>3.318</b>	-1.496	.071	<b>NS</b>
	<b>Private</b>	37	<b>41.05</b>	<b>4.899</b>					

Source: Field survey, (2024).

### Conclusion and Recommendations

The study investigated the laboratory facilities as determinants for secondary school students' interest in chemistry education: a case study of selected secondary schools in Odeda Local Government Area of Ogun State, Nigeria. The findings revealed that although some laboratory facilities are available, they are not sufficient to enhance students' interest in chemistry. The study also found no significant relationship between available laboratory facilities and students' interest in chemistry, suggesting that other factors may be more influential such as attitude, motivation, and learning preferences. Additionally, no significant difference was found in students' interest in chemistry education between students in Faith Heritage College, Abeokuta and Nawair-Ud-Deen Grammar School, Obantoko, Abeokuta, Ogun state, Nigeria. Based on the findings, it is recommended that:

1. Teachers and educators should focus on identifying and addressing other factors that influence students' interest in chemistry, such as attitude, motivation, and learning preferences.
2. The management of secondary schools in the study area should prioritize the provision of adequate laboratory facilities to enhance students' interest in chemistry education.
3. Further research should be conducted to investigate the factors that promote student interest in chemistry in the study area.
4. Stakeholders in education should consider variables such as prior education, parents' education, family income, self-motivation, age of student, and learning preferences when designing strategies to enhance students' interest in chemistry education.



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