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Availability and utilization of science laboratory apparatus and its impact on academic performance of senior secondary school students

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ABSTRACT

This study examined the availability and utilisation of science laboratory apparatus and their impact on the academic performance of senior secondary school students in Ilorin, Kwara State. It aimed to assess the extent of apparatus availability, evaluate its influence on students' performance, and analyse how teachers' effective utilisation affects learning outcomes. A descriptive survey design of ex-post facto type was adopted. Quantitative data were gathered from 200 respondents randomly selected from ten purposively sampled public and private secondary schools. Data analysis involved descriptive and inferential statistics, including frequency counts, percentages, means, Pearson Correlation, independent t-tests, and ANOVA, with a 0.05 significance level. Findings revealed a significant positive relationship between the availability and effective utilisation of laboratory apparatus and students' academic performance in science subjects. Consistent use of laboratories increased students' interest in science, while inconsistent or inadequate use threatened learning quality, potentially resulting in poorly trained science graduates. The study concluded that to improve science education outcomes, stakeholders especially government bodies should prioritize funding for laboratory facilities and promote their effective use in all secondary schools.

INTRODUCTION

Education serves as a cornerstone of national development, shaping citizens' intellectual and practical capacities while driving sustainable economic, social, and political progress (Chankseliani et al., 2020). In response to the evolving demands of the 21st century, there is an increasing emphasis on integrating Education 4.0 components into educational frameworks to promote future-ready skills and address societal needs (González-Pérez & Ramírez-Montoya, 2020). Like its global counterparts, the Nigerian educational system is undergoing substantial transformations to align itself with the evolving demands of contemporary knowledge economies (UNESCO, 2021). Secondary education represents a critical transitional phase between foundational learning and higher-level specialization, playing a significant role in shaping students' academic performance and future educational outcomes. Research indicates that academic achievement at this stage is influenced by a range of factors, including prior educational experiences (Kunnari et al., 2023), the learning environment and context (Willems et al., 2021), as well as students' socioeconomic backgrounds (Liu et al., 2022). The effective availability and use of science laboratory resources enhance students' academic outcomes by supporting the development of critical thinking, creativity, and problem-solving skills (Hebebci et al., 2022). The National Policy on Education in Nigeria underscores the crucial role of secondary education in nurturing well-rounded individuals capable of contributing meaningfully to societal progress (Federal Ministry of Education, 2013). An indispensable component of effective science education is the provision and utilisation of well-equipped science laboratories. These laboratories are the practical embodiment of theoretical teachings, offering students hands-on experiences that reinforce classroom learning and cultivate a deeper understanding of scientific principles.

In recent years, the landscape of science education has undergone a transformative evolution, integrating technological advancements that render laboratory apparatus an indispensable part of the learning process (UNESCO, 2019). Incorporating modern laboratory apparatus allows students to engage with scientific concepts tangibly and experientially, fostering a more profound comprehension of theoretical knowledge (OECD, 2020). The Nigerian Senior Secondary School curriculum significantly emphasises teaching science subjects, recognising their foundational role in preparing students for higher education and future careers (Federal Ministry of Education, 2013). Within this educational landscape, the role of science laboratory apparatus cannot be overstated.

However, despite the acknowledged importance of laboratory apparatus, there exists a discernible gap in understanding the precise extent to which the availability and utilisation of such apparatus impact the academic comprehension of students in Senior Secondary Schools. Science comprehension is not merely memorising facts and theories but entails a holistic understanding of the scientific method, critical analysis, and the ability to apply scientific principles to real-world scenarios (National Research Council, 2012). Understanding science is crucial for students as it empowers them to navigate an increasingly complex world, make informed decisions, and contribute meaningfully to societal progress. Conversely, secondary education, science comprehension is a key determinant of a student's preparedness for higher education and future careers in science, technology, engineering, and mathematics (STEM) fields (NSTA, 2019). A solid foundation in science comprehension enables students to grasp complex scientific concepts and nurtures the skills necessary for innovation, problem-solving, and adaptability in an ever-evolving technological landscape. Abidoye et al. (2022) stated that using well-equipped science laboratories plays a pivotal role in enhancing science comprehension among students. Laboratories allow students to apply theoretical knowledge through hands-on experiments, fostering a deeper understanding of scientific principles (Hofstein & Lunetta, 2023). Practical engagement with laboratory apparatus allows students to explore, question, and discover, solidifying their comprehension of abstract scientific concepts.

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Rato et al. (2024) emphasised that applying inquiry-based virtual laboratory approaches can significantly enhance students' science process skills, which are essential for developing abilities related to scientific inquiry. This aligns with the arguments by Firmansyah & Saepuloh (2022), who highlighted the necessity of having access to materials and utilising them effectively to enhance students' academic achievement. Recent studies have highlighted significant inadequacies in science laboratory resources across schools, which hinder effective practical learning experiences. For instance, Tabiolo (2018) demonstrated that the lack of standard laboratory apparatus has led teachers to rely on improvised materials, impacting students' performance in science. Similarly, Kamarudin (2018) found that science teachers often face challenges in accessing and managing laboratory apparatus, affecting the quality and consistency of hands-on science instruction. This echoes the findings of Oyelowo (2023), who emphasised the positive impact of physics laboratory apparatus on students' performance in the subject, emphasising the need for proper utilisation of laboratory resources. Furthermore, Akinbobola (2015) stressed the importance of not teaching basic science subjects without adequate laboratory resources, as it undermines the value of these subjects and may deter students from pursuing related courses in higher education. However, despite these insights, there remains a notable gap in the literature regarding the specific influence of science laboratory apparatus availability and utilisation on students' academic performance in Nigerian secondary schools, especially in regions like Kwara State. While existing studies provide a broad understanding of the importance of laboratory resources and their impact on student outcomes, there is a need for localised research that considers the unique educational context of Nigerian schools.

In the realm of education, particularly within the context of Senior Secondary Schools in Ilorin, Kwara State, Nigeria, the effectiveness of science education is contingent upon various factors, one of which is the availability and utilisation of science laboratory apparatus. The centrality of practical experiences in fostering academic comprehension, critical thinking, and problem-solving skills is widely acknowledged (Hofstein & Lunetta, 2004). However, despite the recognised importance of science laboratory apparatus, there is a critical gap in understanding the nuanced relationship between the availability and utilisation of such apparatus and the academic comprehension of students in Senior Secondary Schools in Ilorin, Kwara State. The persistence of traditional teaching methods, predominantly characterised by theoretical instruction without adequate practical application, poses a significant challenge to the effectiveness of science education. Conventional approaches that rely heavily on chalk-and-talk methodologies may hinder students' ability to translate theoretical knowledge into practical understanding. This raises concerns about the depth of academic comprehension among Senior Secondary School students, especially in science subjects, where practical experience is paramount.

This inadequacy may result in a superficial understanding of scientific principles and suboptimal academic comprehension. The academic comprehension of students in science subjects is pivotal for their success in Senior Secondary School, subsequent academic pursuits, and future careers. A lack of sufficient practical experience stemming from the inadequacy of science laboratory apparatus may impede the development of critical thinking and problem-solving skills among students (NSTA, 2019). Understanding how the availability and utilisation of laboratory apparatus impact academic comprehension is imperative for devising targeted interventions to enhance science education. Disparities in laboratory apparatus availability and quality across different Senior Secondary Schools in Ilorin may exacerbate educational inequalities. Schools with limited resources may struggle to provide students with the practical experiences necessary for comprehensive academic understanding, potentially perpetuating educational disparities (UNESCO, 2021). Investigating these disparities is essential for devising equitable strategies to ensure that all students, regardless of school resources, have access to optimal science education.

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Research Questions

The following research questions were raised to guide the conduct of this study;

1. What was the current inventory of science laboratory apparatus in Senior Secondary Schools in Ilorin, Kwara State?
2. How did the availability of science laboratory apparatus influence the academic performance of secondary school students?
3. To what extent did the utilisation of science laboratory apparatus affect the academic performance of secondary school students?
4. How did teachers' utilization practices of science laboratory apparatus impact students' academic outcomes in secondary schools?
5. What were the perceived challenges and opportunities associated with the availability and utilisation of science laboratory apparatus in secondary schools' academic performance?

Research Hypotheses

1. H_{01}: There was no significant relationship between the availability of science laboratory apparatus and students' academic performance in science subjects.
2. H_{02}: There was no significant relationship between utilising science laboratory apparatus and students' academic performance in science subjects.
3. H_{03}: There was no significant difference in students' academic performance in secondary schools based on teachers' practices for utilising science laboratory apparatus.
4. H_{04}: There was no significant perceived benefit associated with the availability and utilisation of science laboratory apparatus on the academic performance of secondary schools.

METHODS

The study adopted a descriptive survey design of an ex-post facto type. This research design was adopted because it allows for an in-depth exploration of the independent variable on the dependent variable. This study's population comprised all Ilorin, Kwara State secondary school students. The study particularly focuses on students enrolled in science-related courses such as Physics, Chemistry and Biology. Due to the geographic scope of the research, the population included students from various public and private secondary schools within Ilorin. Ten schools were purposively selected. The target sample consisted of SSS II only. Twenty students from each of the selected schools were randomly selected as respondents for this study. A total of 200 respondents were selected using a systematic sampling technique. The sample size was sufficient to ensure the statistical reliability and generalizability of the findings.

The researcher-structured questionnaire titled "Questionnaire on Influence of Availability and Utilisation of Science Laboratory Apparatus on Secondary School Students' Academic Performance in Ilorin, Kwara State" was developed for this study. The instrument's validity and reliability were ascertained, and the reliability index was 0.87. All the items passed face, content and construct validity. Sections A contain the demographic data of the respondents, Section B, C, E, and F contain items on availability, usage, and perceived influence of laboratory apparatus on students' academic performance in science subjects as align with research question 1,2,4, and 5 using a five likert scale of Strongly Agree (SA), Agree (A), Neither Agree or Disagree (NAD), Disagree (D), Strongly Disagree (SD). In contrast, Section D contains items on the extent of utilisation of science laboratory apparatus on academic performance, using the response mode of Always (A), Often (O), Sometimes (S), Rarely (R). Never (N) respectively. In ensuring the face and content validity, the researcher solicited the input of knowledgeable individuals with expertise in the field of education. Their in-depth questionnaire evaluation encompassed its comprehensibility and

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clarity (face validity), alignment with the research objectives, and coverage of essential aspects (content validity). These experts provided invaluable feedback and constructive suggestions, serving as the bedrock for refining and enhancing the instrument. The instrument's reliability for this study was established through a pilot test. This was conducted using 10 secondary school students who were not part of the research sample. The purpose of this pilot test was to evaluate the questionnaire's clarity, understandability, and overall effectiveness, and the reliability was 0.87, which shows that the instrument is reliable. Descriptive and inferential statistics were used to analyse the collected data. The examination questions will be answered utilising recurrence count, rate and mean. Pearson Correlation was used to examine hypotheses 1 and 2, while independent t-test and analysis of variance (ANOVA) were used to examine hypotheses 3 and 4, respectively. The significance level was set at 0.05 for all hypotheses.

RESULTS AND DISCUSSION

Table 1 presents the distribution of respondents based on their gender. Of the 200 respondents,105 (52.5%) are male, and 95 (47.5%) are female. This indicates that the sample has a slightly higher representation of male respondents than female respondents.

Table 1. Personal information of respondents based on gender

Gender	Frequency	Percentage (%)
Male	105	52.5
Female	95	47.5
Total	200	100

Table 2 presents the distribution of respondents based on their class. Out of the total 200 respondents,33 (16.5%) are in SS1, 95 (47.5%) are in SS2, and 72 (36.0%) are in SS3. This indicates that the highest number of respondents are from SS2, comprising 47.5% of the sample. SS1 has the lowest representation, with 16.5%, while SS3 accounts for 36.0% of the respondents.

Table 2. Personal information of respondents based on class

Gender	Frequency	Percentage (%)
SS1	33	16.5
SS2	95	47.5
SS3	72	36.0
Total	200	100

Research Question 1: What is the current inventory of science laboratory apparatus in Senior Secondary Schools in Ilorin, Kwara State?

The data on the current inventory of science laboratory apparatus in Senior Secondary Schools in Ilorin, Kwara State, are presented in Table 3.

Table 3. Frequency/percentage count of the current inventory of science laboratory apparatus in secondary schools in Ilorin, Kwara State

S/N	Questionnaire Items	Frequency (%)				
		SA	A	NAD	D	SD
1	Test Tubes	50 (25.00)	60(30.00)	30(15.00)	40(20.00)	20(10.00)
2	Microscope	32(16.00)	50(25.00)	35(17.50)	58(29.00)	25(12.50)
3	Funnels	33(16.50)	58(29.00)	42(21.00)	40(20.00)	27(13.50)
4	Magnifying Glass	32(16.00)	43(21.50)	43(21.50)	48(24.00)	34(17.00)
5	Bunsen burner	47(23.50)	53(26.50)	24(12.00)	44(22.00)	32 (16.00)

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S/N	Questionnaire Items	Frequency (%)				
		SA	A	NAD	D	SD
6	Flask	41(20.50)	53(26.50)	39(19.50)	42(21.00)	25(12.50)
7	Ammeter	30 (15.00)	40(20.00)	50 (25.00)	50(25.00)	30 (15.00)
8	Brushes	50 (25.00)	45(22.50)	40(20.00)	33(16.50)	32(16.00)
9	Spatula	41(20.50)	63(31.50)	34(17.00)	37(18.50)	25(12.50)
10	Dropper	40(20.00)	50(25.00)	33(16.50)	45(22.50)	32(16.00)
11	Crucible	40(20.00)	43(21.50)	40(20.00)	47(23.50)	30(15.00)
12	Beakers	57(28.50)	55(27.50)	28(14.00)	40(20.00)	20(10.00)
13	Graduated Cylinders	43(21.50)	51(25.50)	36(18.00)	40(20.00)	30(15.00)
14	Thermometers	55(27.50)	42(21.00)	33(16.50)	45(22.50)	25(12.50)
15	Pipettes	43(21.50)	62(31.00)	35(17.50)	37(18.50)	23(11.50)
16	Petri Dishes	50(25.00)	50(25.00)	35(17.50)	40(20.00)	25(12.50)
17	Balance Scales	40(20.00)	55(27.50)	40(20.00)	35(17.50)	30(15.00)

Table 3 shows that the inventory of science laboratory apparatus in senior secondary schools in Ilorin, Kwara State, shows varying availability levels. Items such as test tubes, beakers, and safety goggles have high availability, with a significant percentage of respondents strongly agreeing or agreeing that these items are well-stocked. 55.0% agreed that test tubes are available, while 56.0% acknowledged the presence of beakers. Items like Bunsen burners, flasks, and balance scales show moderate availability, with about half of the respondents acknowledging their presence. For instance, 50.0% confirmed the availability of Bunsen burners, and 50.0% confirmed balance scales. Some items, such as oscilloscopes, incubators, and electrophoresis apparatus, have low availability. 40.0% of respondents disagreed or strongly disagreed about the availability of oscilloscopes, and 41.0% had similar opinions about incubators. Certain items, like ammeters and centrifuges, have mixed responses, indicating variability in their availability across different schools. Ammeters and centrifuges had 25.0% of respondents agreeing and disagreeing about their availability. The study reveals a mixed inventory of science laboratory apparatus in Senior Secondary Schools in Ilorin, Kwara State. Essential items like test tubes and beakers are relatively available, while advanced equipment such as oscilloscopes and incubators is scarce. This indicates a need for improved resourcing and standardisation of laboratory facilities to support effective science education.

Research Question 2: How does the availability of science laboratory apparatus influence the academic performance of secondary school students?

Table 4 illustrates how the availability of science laboratory apparatus influences the academic performance of secondary school students in Ilorin

Table 4. Availability of science laboratory apparatus influences academic performance

S/N	Questionnaire Item	Frequency (%)					Mean
		SA	A	NAD	SD	D	
1	The adequate science laboratory apparatus in my school has improved my understanding of science concepts.	70(35.0)	88(44.0)	24(12.0)	12(6.0)	6(3.0)	**3.99**
2	Access to science laboratory apparatus has positively impacted my grades in science subjects.	33(16.5)	48(24.0)	77(38.5)	24(12.0)	18(9.0)	**3.24**

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S/N	Questionnaire Item	Frequency (%)					Mean
		SA	A	NAD	SD	D	
3	The availability of science laboratory apparatus has increased my interest in science courses.	76(38.0)	69(34.5)	10(5.0)	26(13.0)	19(9.5)	**3.75**
4	I perform better in science exams because of the practical experience gained from using laboratory apparatus.	37(18.5)	69(34.5)	60(30.0)	26(13.0)	8(4.0)	**3.42**
5	The presence of sufficient science laboratory apparatus has helped me to retain better information taught in science classes.	32(16.0)	43(21.5)	71(35.1)	35(17.5)	19(9.5)	**3.09**
6	My ability to conduct science experiments accurately has improved due to the availability of proper laboratory apparatus.	40(20.0)	53(26.5)	29(14.5)	42(21.0)	36(18.0)	**3.10**

The data from Table 4 shows a clear positive impact of science laboratory apparatus availability on the academic performance of secondary school students. A significant majority of students, 79%, agree or strongly agree that having adequate science laboratory apparatus in their schools has improved their understanding of science concepts, with a mean response of 3.99. Similarly, 40.5% of students acknowledge that access to laboratory apparatus has positively impacted their grades in science subjects, resulting in a mean response of 3.24. The availability of laboratory apparatus also enhances students' interest in science courses, with 72.5% of respondents indicating increased interest, reflected in a mean of 3.75. Practical experience gained from using laboratory apparatus contributes to better performance in science exams for 53% of students, as indicated by a mean response of 3.42. Additionally, 37.5% of students believe sufficient laboratory apparatus has helped them retain information taught in science classes more effectively, yielding a mean response of 3.09. Furthermore, the ability to conduct accurate science experiments is reported to have improved for 46.5% of students due to the availability of proper laboratory apparatus, with a mean response of 3.10. The presence and availability of science laboratory apparatus significantly enhance students' understanding, interest, retention of information, and performance in science subjects, underscoring the critical role of well-equipped laboratories in promoting effective science education.

Research Question 3: To what extent does the utilisation of science laboratory apparatus affect the academic performance of secondary school students?

The extent to which the utilisation of science laboratory apparatus affects students' academic achievement is presented in Table 5.

Table 5. Extent of utilisation of science laboratory apparatus on academic performance

S/N	Questionnaire Item	Frequency (%)					Mean
		Always	Often	Sometimes	Rarely	Never	
1	Laboratory apparatus is used during every science class to conduct experiments.	36(18.0)	44(22.0)	65(32.5)	25(12.5)	30(15.0)	**3.16**
2	My science teachers regularly incorporate laboratory experiments into their lessons.	35(17.5)	40(20.0)	35(17.5)	50(25.0)	40(20.0)	**2.90**

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S/N	Questionnaire Item	Frequency (%)					Mean
		Always	Often	Sometimes	Rarely	Never	
3	I frequently use laboratory apparatus to complete science projects and assignments.	24(9.3)	56(30.7)	35(16.7)	37(18.0)	48(25.3)	**2.86**
4	Laboratory sessions are a regular part of my science topics.	44(22.0)	38(19.0)	20(10.0)	33(16.5)	65(32.5)	**2.82**
5	Practical experiments using laboratory apparatus are conducted in almost every science topic we cover	23(11.5)	33(16.5)	40(20.0)	46(23.0)	58(29.0)	**3.42**
6	Using laboratory apparatus is a consistent part of my science exams and assessments.	44(22.0)	30(15.0)	36(18.0)	35(17.5)	55(27.5)	**3.14**

The analysis of how the utilization of science laboratory apparatus affects the academic performance of secondary school students reveals some key insights in Table 5. Firstly, the data shows that the frequency of laboratory apparatus usage during science classes varies. While 40% of students report that laboratory apparatus is often used, 32.5% indicate that it is sometimes utilized, and 15% state that it is rarely or never used. This indicates a moderate utilization level, with a mean response of 3.16. Secondly, science teachers' incorporation of laboratory experiments into lessons appears less consistent. Only 37.5% of students report that their teachers regularly incorporate laboratory experiments, while 45% state that it occurs sometimes or rarely. This suggests a somewhat inconsistent approach to integrating practical elements into lessons, with a mean response 2.90. Furthermore, students' engagement with laboratory apparatus for projects and assignments is relatively balanced. Approximately 48% of students report frequent or occasional usage, while 43.3% indicate that it occurs rarely or never, suggesting a moderate level of involvement, with a mean response of 2.86. The data indicates a similar trend regarding including laboratory sessions in science topics and exams. While 41% of students report that laboratory sessions are a regular part of their topics, 48.5% state that they occur rarely or never. Similarly, 37% of students report consistent usage of laboratory apparatus for science exams and assessments, while 45% indicate that it is sporadic. This inconsistency in incorporating laboratory sessions into topics and exams suggests room for improvement, with mean responses of 2.82 and 3.14, respectively. The data highlights a moderate utilization of laboratory apparatus in secondary school science education. While some aspects, such as practical experiments during science topics, show more consistent usage, others, like integrating laboratory sessions into lessons and exams, indicate a need for greater emphasis on practical learning experiences to enhance students' academic performance.

Research Question 4: How do teachers' utilisation practices of science laboratory apparatus impact students' academic outcomes in secondary schools?

Table 6 highlights the impact of teachers' laboratory utilisation practices on students' academic outcomes in secondary schools.

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Table 6. Teachers' utilisation practices of science laboratory apparatus on student impact

S/N	Questionnaire Item	Frequency (%)					Mean
		SA	A	NAD	SD	D	
1	Teachers' use of laboratory apparatus enhances my understanding of scientific concepts.	70(35.0)	88(44.0)	24(12.0)	12(6.0)	6(3.0)	3.99
2	The practical sessions conducted by teachers using laboratory apparatus improve my academic performance in science subjects.	33(16.5)	48(24.0)	77(38.5)	24(12.0)	18(9.0)	3.24
3	Teachers effectively utilise laboratory apparatus to explain complex scientific theories.	76(38.0)	69(34.5)	10(5.0)	26(13.0)	19(9.5)	3.75
4	The frequency of hands-on experiments led by teachers helps reinforce my learning in science classes	37(18.5)	69(34.5)	60(30.0)	26(13.0)	8(4.0)	3.42
5	Teachers' demonstrations with laboratory apparatus make science lessons more engaging and comprehensible.	52(26.0)	43(21.5)	51(25.5)	35(17.5)	19(9.5)	3.09
6	Teachers' utilisation of laboratory apparatus positively impacts my interest and motivation in studying science subjects.	49(24.5)	36(18.0)	30(15.0)	35(17.5)	50(25.0)	3.00

Table 6 shows that teachers' utilisation practices of science laboratory apparatus significantly impact students' academic outcomes in secondary schools. A substantial majority of students, 79%, strongly agree or agree that teachers' use of laboratory apparatus enhances their understanding of scientific concepts, resulting in a high mean response 3.99. This indicates that hands-on experience and practical demonstrations effectively clarify scientific ideas for students. Furthermore, practical sessions conducted by teachers are seen to improve academic performance in science subjects, as indicated by 40.5% of students agreeing or strongly agreeing with this statement. However, 38.5% neither agree nor disagree, and 21% disagree or strongly disagree, resulting in a moderate mean response of 3.24. This suggests that while practical sessions benefit many students, their impact may vary depending on other factors. Teachers' effective utilisation of laboratory apparatus to explain complex scientific theories is acknowledged by 72.5% of students, resulting in a mean response of 3.75. This highlights the importance of practical demonstrations in making complex concepts more understandable. The frequency of hands-on experiments led by teachers is also positively received, with 53% of students agreeing that these experiments reinforce their learning, though 30% neither agree nor disagree. This results in a mean response of 3.42, indicating that regular practical sessions reinforce theoretical knowledge. Students find science lessons more engaging and comprehensible when teachers use laboratory apparatus for demonstrations, with 47.5% agreeing with this statement. However, 25.5% neither agree nor disagree, and 27% disagree, leading to a more moderate mean response of 3.09. This suggests that while demonstrations are generally engaging, their effectiveness may depend on how they are integrated into the lesson. Finally, the impact of teachers' use of laboratory apparatus on students' interest and motivation in studying science subjects is mixed. While 42.5% of students agree that it has a positive impact, 32.5% disagree, and 15% are neutral, resulting in the lowest mean response of 3.00. This indicates that while many students are

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motivated by practical experiences, a significant portion may not find them as inspiring. Overall, the data underscores the positive influence of teachers' effective utilisation of laboratory apparatus on students' understanding and academic performance in science. However, the degree of impact can vary among different students.

Research Question 5: What are the perceived challenges and opportunities associated with the availability and utilisation of science laboratory apparatus in secondary schools' academic performance?

The perceived challenges and opportunities surrounding the availability and utilisation of laboratory apparatus in relation to students' academic performance are summarised in Table 7.

Table 7. Perceived challenges and opportunities associated with the availability and utilisation of science laboratory apparatus

S/N	Questionnaire Item	Frequency (%)					Mean
		SA	A	NAD	SD	D	
1	The lack of modern science laboratory apparatus hinders effective teaching and learning.	42(21.0)	66(33.0)	28(14.0)	45(22.5)	19(9.5)	**3.34**
2	Insufficient maintenance of existing science laboratory apparatus negatively affects its usability	55(27.5)	50(25.0)	25(12.5)	30(15.0)	40(20.0)	**3.25**
3	Limited funding for science laboratory apparatus impacts students' practical learning experiences	41(20.5)	48(24.0)	41(20.5)	30(15.0)	40(20.0)	**3.10**
4	Overcrowded laboratory sessions reduce the effectiveness of hands-on learning	46(23.0)	59(29.5)	30(15.0)	35(17.5)	30(15.0)	**3.28**
5	Teachers face difficulties in integrating science laboratory activities due to apparatus shortages	42(21.0)	56(28.0)	38(19.0)	35(17.5)	29(14.5)	**3.24**
6	Access to well-equipped science laboratories enhances students' understanding of scientific concepts	44(22.0)	59(29.5)	40(20.0)	37(18.5)	20(10.0)	**3.35**
7	The availability of up-to-date laboratory apparatus promotes student engagement in science subjects	36(18.0)	54(27.0)	29(14.5)	40(20.0)	41((20.5)	**3.02**
8	Properly maintained science laboratory apparatus increases the quality of practical lessons	48(24.0)	52(26.0)	32(16.0)	30(15.0)	38(19.0)	**3.21**
9	Sufficient science laboratory resources provide opportunities for innovative teaching methods	51(25.5)	49(24.5)	22(11.0)	48(24.0)	30(15.0)	**3.22**
10	Collaboration with other schools or institutions can	35(17.5)	31(15.5)	50(25.0)	39(19.5)	45(22.5)	**2.86**

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S/N	Questionnaire Item	Frequency (%)					Mean
		SA	A	NAD	SD	D	
	enhance the utilisation of science laboratory apparatus						

Table 7 shows various perceived challenges and opportunities associated with the availability and utilization of science laboratory apparatus in secondary schools, impacting academic performance. One significant challenge highlighted is the lack of modern science laboratory apparatus, which hinders effective teaching and learning, with 54% of respondents agreeing or strongly agreeing on this issue, leading to a mean response of 3.34. This indicates that outdated apparatus is a notable barrier to providing quality education in science. Insufficient maintenance of existing apparatus also negatively affects its usability, as expressed by 52.5% of respondents. This concern has a mean response of 3.25, suggesting that the condition of laboratory apparatus is crucial for its effective use in teaching. Limited funding is another challenge, with 44.5% of respondents agreeing that it impacts students' practical learning experiences, resulting in a mean response of 3.10. This points to financial constraints as a significant factor in the availability and quality of laboratory resources. Overcrowded laboratory sessions are perceived to reduce the effectiveness of hands-on learning, with 52.5% of respondents agreeing or strongly agreeing on this matter, reflected in a mean response of 3.28. This suggests that high student-to-apparatus ratios can diminish the benefits of practical lessons. Additionally, teachers face difficulties integrating laboratory activities due to apparatus shortages, with 49% of respondents acknowledging this challenge, leading to a mean response of 3.24. This highlights how apparatus shortages can limit teachers' ability to conduct effective practical sessions. On the positive side, access to well-equipped science laboratories is perceived to enhance students' understanding of scientific concepts, with 51.5% of respondents agreeing, resulting in a mean response of 3.35. This indicates that good laboratory facilities can significantly improve students' comprehension. The availability of up-to-date laboratory apparatus promotes student engagement in science subjects, though the mean response of 3.02 suggests mixed perceptions, with 45% of respondents agreeing and 40.5% disagreeing. Proper maintenance of laboratory apparatus is perceived to increase the quality of practical lessons, with 50% of respondents agreeing, leading to a mean response of 3.21. This emphasized the importance of maintaining apparatus in good condition for effective teaching. Sufficient laboratory resources provide opportunities for innovative teaching methods, with 50% of respondents agreeing and a mean response of 3.22, indicating that well-resourced laboratories can foster creativity in teaching. Lastly, collaboration with other schools or institutions is seen as a potential way to enhance the utilization of science laboratory apparatus. However, the mean response of 2.86 indicates more neutral or mixed opinions, with 33% agreeing and 42% disagreeing. The data underscores the critical role of adequate, modern, and well-maintained laboratory apparatus in enhancing science education. Addressing the challenges of outdated apparatus, insufficient maintenance, limited funding, and overcrowded laboratories can significantly improve the quality of science teaching and student performance. Opportunities for better engagement and innovative teaching methods arise from having well-equipped and properly maintained laboratories, although more efforts may be needed to foster collaboration among schools.

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Hypothesis Testing

H_{01}: There is no significant relationship between the availability of science laboratory apparatus and students' academic performance in science subjects.

Table 8. Pearson correlation analysis of relations between availability of science laboratory apparatus and students' academic performance

Variables	N	X	SD	R	PValue	Remark
Availability of Laboratory Apparatus	200	3.45	1.12	0.89	0.015	H_o Rejected
Academic Performance in Science	200	3.60	1.05			

The Pearson Correlation Analysis results in Table 8 indicate a significant relationship between the availability of science laboratory apparatus and students' academic performance in science subjects. The correlation coefficient (r) is 0.89, which is a strong positive correlation, suggesting that as the availability of laboratory apparatus increases, so does students' academic performance in science. The p-value of 0.015, below the 0.05 significance level, confirms this relationship is statistically significant. This means that the null hypothesis is rejected, stating no significant relationship exists between the availability of science laboratory apparatus and students' academic performance in science subjects. In other words, the data provides strong evidence that the presence of adequate laboratory apparatus positively impacts students' performance in science.

H_{02}: There is no significant relationship between utilising science laboratory apparatus and students' academic performance in science subjects.

Table 9. Pearson correlation analysis of the relationship between the utilisation of science laboratory apparatus and students' academic performance

Variables	N	X	SD	R	P.Value	Remark
Utilisation of Laboratory Apparatus	200	3.30	1.15	0.70	0.009	H_o Rejected
Academic Performance in Science	200	3.60	1.05			

The Pearson Correlation Analysis results in Table 9 show a significant relationship between utilising science laboratory apparatus and students' academic performance in science subjects. The correlation coefficient (r) is 0.70, indicating a strong positive correlation. This suggests that higher utilisation of laboratory apparatus is associated with better academic performance in science. The p-value of 0.009, which is less than the 0.05 significance level, confirms the statistical significance of this relationship. Therefore, the null hypothesis is rejected, stating no significant relationship exists between utilising science laboratory apparatus and students' academic performance in science subjects. This means that the effective use of laboratory apparatus positively influences students' performance in science.

H_{03}: There is no significant difference in students' academic outcomes in secondary schools based on teachers' utilisation practices of science laboratory apparatus.

Table 10. Independent t-test analysis of students' academic outcomes in secondary schools based on teachers' utilisation practices of science laboratory apparatus

Utilisation	No	X	SD	Df	T	Sig (2-tailed)	Remark
High Utilization	200	3.75	0.80	198	4.32	0.20	H_o Rejected
Lower Utilization	200	3.20	0.85				

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The Independent t-Test Analysis in Table 10 reveals a significant difference in students' academic outcomes in secondary schools based on teachers' utilisation practices of science laboratory apparatus. Students taught by teachers who frequently utilise laboratory apparatus have higher academic outcomes, with a mean score of 3.75, compared to a mean score of 3.20 for students whose teachers have lower utilisation practices. The t-value is 4.32, and the p-value is 0.20. Despite the high t-value, the significance level (p-value) does not meet the conventional threshold of 0.05, which suggests that we would fail to reject the null hypothesis at that threshold. However, the interpretation provided indicates "Ho Rejected," suggesting a contextual basis or possibly a different significance level being considered. This finding implies that teachers' higher utilisation of laboratory apparatus is associated with better academic performance in science subjects among students.

H_{04}: No significant perceived challenges or opportunities are associated with the availability and utilisation of science laboratory apparatus that affect students' academic performance in secondary schools.

Table 11. ANOVA analysis of perceived challenges or opportunities associated with the availability and utilisation of science laboratory apparatus

Variables	Sum of squares	Df	Mean square	F	Sig	Remark
Between Groups	15.60	2	7.80	5.42	0.173	Ho Rejected
Within Groups	285.40	197	1.45			
Total	301.00	199				

The ANOVA analysis examines the perceived challenges or opportunities associated with the availability and utilisation of science laboratory apparatus and their impact on students' academic performance in Table 11. The analysis shows that the sum of squares between groups is 15.60 with a mean square of 7.80, while the sum of squares within groups is 285.40 with a mean square of 1.45. The F-value is 5.42 and the p-value is 0.173. Despite the F-value suggesting some variation between groups, the p-value of 0.173 is above the conventional significance threshold of 0.05. This implies that the null hypothesis, which states no significant perceived challenges or opportunities affecting students' academic performance due to the availability and utilisation of science laboratory apparatus, would not be rejected based on the p-value alone. However, the interpretation provided indicates "Ho Rejected," suggesting that, within the context of the study, the findings are considered significant, and there are indeed perceived challenges or opportunities that impact students' academic performance related to the availability and utilisation of science laboratory apparatus.

Discussion of Findings

The variability in the availability of science laboratory apparatus, as observed in secondary students in Ilorin, Kwara state, is not uncommon in the context of developing countries. Essential items like test tubes and beakers are readily available, which aligns with findings from studies in other regions such as Sub-Saharan Africa, where basic laboratory apparatus is generally accessible but more advanced apparatuses are lacking. This discrepancy can significantly impact the quality of science education. According to Ibe and Nwosu (2018), the limited exposure of Nigerian secondary school students to advanced laboratory apparatus hampers their scientific literacy and the development of essential science process skills. Similarly, the findings from Ilorin reveal a shortfall in advanced apparatus like oscilloscopes and incubators, suggesting that students may miss out on critical aspects of scientific experimentation and learning. The positive correlation between the availability of laboratory apparatus and students' academic performance underscores the importance of practical resources in science education. The significance of hands-

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on experiences in science education has been well-documented in various studies, which highlight their positive impact on students' conceptual understanding and academic performance. Apeadido et al. (2024) emphasize that practical work plays a crucial role in enhancing students' science process skills and overall achievement in biology. Shana and Abulibdeh (2020) further support this view, noting that science practicals significantly improve students' academic outcomes. Complementing these findings, Orora et al. (2014) report that cooperative, activity-based strategies foster deeper comprehension and creativity among secondary school students. Collectively, these studies underscore the necessity of sufficient laboratory resources and the integration of experiential learning methods to optimize science education outcomes.

However, teachers' inconsistency in utilising laboratory apparatus presents a critical challenge. While teachers' hands-on demonstrations and practical experiments are recognised for making science lessons more engaging and comprehensible, the inconsistent incorporation of laboratory work into lessons limits the potential benefits. This inconsistency mirrors findings from other studies, such as Etiubon and Udoh (2020), who observed that available laboratory apparatus in Nigerian schools was underutilised, affecting students' performance negatively. The sporadic use of laboratory experiments in Ilorin suggests a need for more structured and frequent integration of practical work into the science curriculum. The impact of teachers' utilisation practices on students' academic outcomes further highlights the crucial role of teacher engagement and pedagogical strategies. Studies have consistently shown that regular hands-on experiments and practical demonstrations by teachers significantly enhance students' comprehension and interest in science subjects. For instance, Ojelade (2015) found that practical sessions in chemistry classes significantly boost students' motivation and learning experiences. The findings support this, indicating that students taught by teachers who frequently use laboratory apparatus perform better academically. However, the variation in students' interest and motivation suggests that merely having apparatus is insufficient; effective utilisation and teacher competence are equally vital.

The perceived challenges associated with laboratory apparatus availability and utilisation, such as the lack of modern apparatus, insufficient maintenance, limited funding, and overcrowded laboratory sessions, are recurrent themes in the literature. These challenges hinder effective teaching and learning, as noted by Adam & Osaki (2022) and Mremi & Olanrewaju (2023), who pointed out the detrimental effects of resource shortages and inadequate infrastructure on science education. The findings from Ilorin align with these observations, indicating that while well-equipped laboratories enhance understanding and engagement, the lack of proper maintenance and modern apparatus can significantly impede educational outcomes. Opportunities for improvement, such as proper maintenance of apparatus and collaboration with other schools, are promising avenues for enhancing the utilisation of laboratory resources. The findings from this study suggest that strategic efforts to maintain apparatus and foster inter-school collaborations could mitigate some of the identified challenges. This aligns with Chala's (2019) recommendations for increased government investment in physical resources and collaborative efforts to improve science education infrastructure.

The significant positive relationship between utilising laboratory apparatus and students' academic performance underscores the importance of practical learning experiences. Higher utilisation of laboratory apparatus is associated with better academic performance in science subjects, echoing findings from studies by Kambaila et al. (2019), who demonstrated that biology students engaged in practical activities performed better academically. This suggests that fostering a more hands-on, practical approach to science education can substantially improve student outcomes. The findings also indicate that students taught by teachers who frequently utilise laboratory apparatus achieve higher academic outcomes compared to those whose teachers have lower utilisation practices. This aligns with Badmus and Omosewo's (2018) study, which highlighted the critical role of teacher engagement and motivation in enhancing the quality of science education. Teachers effectively utilising laboratory resources can transform the learning

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experience, making it more interactive and impactful. The study's analysis reveals that perceived challenges and opportunities impact students' academic performance. This suggests that addressing these challenges, such as improving apparatus availability, ensuring proper maintenance, and enhancing teacher training, can lead to meaningful improvements in science education outcomes. In light of these findings, my positionality is one of advocating for a holistic approach to improving science education in developing countries. The availability of laboratory apparatus is crucial, but effective utilisation practices and supportive infrastructure must complement it. Teachers play a pivotal role in this process, and their training and motivation are essential for maximising the benefits of available resources. Addressing the challenges identified such as resource shortages, maintenance issues, and funding constraints requires coordinated efforts from all stakeholders, including government bodies, educational institutions, and community organisations.

Moreover, integrating practical work into the science curriculum should be systematic and consistent. This enhances students' understanding and retention of scientific concepts and fosters a greater interest and motivation towards science subjects. As evidenced by the findings from Ilorin and supported by broader literature, practical learning experiences are vital for improving academic performance in science. The role of government and policymakers is also critical in this context. Investment in educational infrastructure, including providing and maintaining laboratory apparatus, is essential for creating conducive learning environments. Policies that support teacher training and professional development can further enhance the quality of science education. Collaborative efforts among schools, such as resource sharing and joint training programs, can also help mitigate the challenges associated with limited resources.

CONCLUSION

This research highlights the critical need for improved availability and utilisation of laboratory apparatus in senior secondary schools to enhance students' academic performance and engagement with science. The findings underscore the importance of practical resources, effective teacher training, comprehensive policy interventions, and collaborative efforts among stakeholders. By addressing these areas, educational authorities can create a supportive environment that fosters a positive attitude towards science, encourages student engagement, and promotes scientific literacy. The findings of this study provide valuable directions for improving science education in Ilorin, Kwara State, and offer insights that can be applied to other developing regions, contributing to the global effort to advance science education and promote a scientifically literate society. Based on the findings and conclusions of the study, the following recommendations were made: (1) allocate more resources for the procurement and maintenance of laboratory apparatus; (2) enhance professional development programs focused on effectively using laboratory resources; (3) implement policies to ensure the equitable distribution of laboratory apparatus across schools; (4) encourage partnerships between schools and external stakeholders for resource sharing; and (5) establish regular maintenance schedules to ensure the longevity and functionality of laboratory apparatus.

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