

**THE IMPACT OF INADEQUATE LABORATORY FACILITY ON STUDENTS' ACADEMIC
PERFORMANCE IN INTEGRATED SCIENCE IN FEDERAL COLLEGE OF EDUCATION
(TECHNICAL), OMOKU, RIVERS STATE**

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Abstract

This study investigated the impact of inadequate laboratory facilities on students' academic performance in Integrated Science at the Federal College of Education (Technical), Omoku, Rivers State. The descriptive survey research design was employed to examine the relationship between laboratory facility adequacy and academic performance among 240 NCE II students. Data were collected using structured questionnaires and analyzed using descriptive statistics, Pearson correlation, and t-tests. Results revealed significant positive correlations between laboratory equipment adequacy ($r = 0.678$, $p < 0.05$), laboratory space adequacy ($r = 0.592$, $p < 0.05$), and academic performance. Students with access to adequate laboratory facilities demonstrated significantly higher academic performance ($M = 3.42$, $SD = 0.68$) compared to those with inadequate facilities ($M = 2.78$, $SD = 0.54$). The study concluded by emphasizing that inadequate laboratory facilities significantly impair students' academic performance in Integrated Science. Consequently, it was recommended amongst others that immediate upgrade of laboratory infrastructure, procurement of modern equipment, and establishment of maintenance protocols be put in place to enhance students' performance in Integrated Science.

Keywords: Laboratory Facilities, Academic Performance, Integrated Science, Teacher Education and Educational Infrastructure

1. Introduction

The quality of educational infrastructure, particularly laboratory facilities, plays a crucial role in determining students' academic outcomes in science education (Adeyemi & Adeyemi, 2014). In Nigeria's educational system, the challenge of inadequate laboratory facilities has persisted as a major impediment to effective science teaching and learning, particularly in teacher training institutions (Okoro & Okoro, 2016). The Federal College of Education (Technical), Omoku, as a premier teacher training institution in Rivers State, faces similar challenges that potentially affect the quality of science teacher preparation.

Laboratory facilities serve as the cornerstone of practical science education, providing students with hands-on experiences that bridge the gap between theoretical knowledge and practical application (Hofstein & Lunetta, 2014). Research has consistently demonstrated that well-equipped laboratories enhance students' understanding of scientific concepts, improve their problem-solving skills, and foster positive attitudes toward science learning (Abrahams & Millar, 2008). However, the reality in many Nigerian educational institutions presents a stark contrast to these ideals, with reports of inadequate equipment, insufficient space, and poor maintenance of existing facilities (Ezeudu & Obi, 2013).

The significance of laboratory work in Integrated Science education cannot be overstated, as it encompasses multiple scientific disciplines including physics, chemistry, and biology. Students require access to diverse equipment and resources to conduct experiments across these domains effectively (Johnstone & Al-Shuaili, 2001). The integrated nature of the subject demands well-equipped laboratories that can accommodate various practical activities, from simple observations to complex experimental procedures (White, 1996).

Research conducted by Tamir (1991) established that students who engage in regular laboratory activities demonstrate superior performance in both practical and theoretical assessments compared to their counterparts with limited laboratory exposure. Similarly, studies by Lazarowitz and Tamir (1994) revealed that adequate laboratory facilities contribute significantly to students' conceptual understanding and retention of scientific knowledge. These findings underscore the critical importance of well-equipped laboratories in science education.

The Nigerian educational context presents unique challenges regarding laboratory facility provision. Studies by Ogunniyi (2006) highlighted the persistent problems of inadequate funding, poor infrastructure maintenance, and insufficient equipment procurement in Nigerian schools and colleges. These challenges are particularly pronounced in teacher training institutions, where the quality of science teacher preparation directly impacts the broader educational system (Jekayinfa, 2006).

Recent investigations by Adegoke (2011) and Igwebuikwe and Oriafio (2017) have documented the widespread nature of laboratory inadequacies in Nigerian higher education institutions. These studies reveal common problems including obsolete equipment, insufficient laboratory space, lack of consumables, and poor maintenance culture. The cumulative effect of these deficiencies is reflected in students' poor performance in science subjects and declining interest in science careers (Okoye, 2009).

The Federal College of Education (Technical), Omoku, established to train technical and science teachers for secondary schools, faces particular challenges in maintaining adequate laboratory facilities for its Integrated Science program. The institution serves a large student population from diverse socio-economic backgrounds, placing additional strain on existing resources (Rivers State Ministry of Education, 2018). Understanding the specific impact of laboratory inadequacies on student performance in this context is essential for developing targeted interventions.

International research provides additional perspective on the laboratory-performance relationship. Studies by Hofstein and Mamlok-Naaman (2007) in Israel and Bennett (2003) in the United Kingdom have consistently shown positive correlations between laboratory quality and student achievement in science subjects. These international findings provide benchmarks for understanding the potential impact of laboratory improvements on student outcomes.

The theoretical framework for this study draws from constructivist learning theory, which emphasizes the importance of hands-on experiences in knowledge construction (Vygotsky, 1978). According to this perspective, laboratory activities provide essential opportunities for students to construct scientific understanding through direct manipulation of materials and

observation of phenomena (Driver et al., 1994). When laboratory facilities are inadequate, these crucial learning opportunities are compromised, potentially leading to reduced academic performance.

1.2. Statement of the Problem

Despite the recognized importance of laboratory facilities in science education, many Nigerian higher education institutions, including the Federal College of Education (Technical), Omoku, continue to grapple with inadequate laboratory infrastructure. Preliminary observations at the institution reveal concerning deficiencies in laboratory equipment, space, and maintenance that may be impacting students' academic performance in Integrated Science.

Research by Ezeudu and Obi (2013) documented widespread laboratory inadequacies in Nigerian educational institutions, noting that over 70% of surveyed institutions lacked basic equipment necessary for effective science teaching. Similarly, Okoro and Okoro (2016) found that inadequate laboratory facilities significantly correlated with poor student performance in science subjects across Nigerian colleges of education. Furthermore, Adeyemi and Adeyemi (2014) established that students in institutions with well-equipped laboratories demonstrated significantly higher achievement levels compared to those in poorly equipped institutions.

The persistence of these challenges raises critical questions about their specific impact on student learning outcomes in Integrated Science at the Federal College of Education (Technical), Omoku. While anecdotal evidence suggests that inadequate laboratory facilities may be contributing to poor academic performance among students, empirical investigation is needed to establish the nature and extent of this relationship. Understanding this relationship is crucial for informing policy decisions and resource allocation strategies aimed at improving educational quality in the institution.

1.3 Purpose of the Study

The purpose of the study was to investigate the impact of inadequate laboratory facilities on students' academic performance in Integrated Science at the Federal College of Education (Technical), Omoku, Rivers State. Specifically, the study was carried out to:

1. Examine the relationship between laboratory equipment adequacy and students' academic performance in Integrated Science at the Federal College of Education (Technical), Omoku.
2. Assess the relationship between laboratory space adequacy and students' academic performance in Integrated Science at the Federal College of Education (Technical), Omoku.
3. Determine the relationship between laboratory maintenance quality and students' academic performance in Integrated Science at the Federal College of Education (Technical), Omoku.

1.4. Research Questions

The following research questions guided this study:

1. What is the relationship between laboratory equipment adequacy and students' academic performance in Integrated Science at the Federal College of Education (Technical), Omoku?
2. What is the relationship between laboratory space adequacy and students' academic performance in Integrated Science at the Federal College of Education (Technical), Omoku?
3. What is the relationship between laboratory maintenance quality and students' academic performance in Integrated Science at the Federal College of Education (Technical), Omoku?

1.5. Research Hypotheses

The following null hypotheses were tested at 0.05 level of significance:

H₀₁: There is no significant relationship between laboratory equipment adequacy and students' academic performance in Integrated Science at the Federal College of Education (Technical), Omoku.

H₀₂: There is no significant relationship between laboratory space adequacy and students' academic performance in Integrated Science at the Federal College of Education (Technical), Omoku.

H₀₃: There is no significant relationship between laboratory maintenance quality and students' academic performance in Integrated Science at the Federal College of Education (Technical), Omoku.

2. Literature Review

2.1 Theoretical Framework

The theoretical foundation for this study is anchored on several interconnected learning theories that explain the relationship between laboratory facilities and academic performance in science education.

2.1.1 Constructivist Learning Theory

The constructivist learning theory, pioneered by Piaget (1977) and later developed by Vygotsky (1978), provides the primary theoretical framework for understanding how laboratory experiences contribute to student learning. According to constructivist principles, learners actively construct knowledge through hands-on experiences and interaction with their environment (Brooks & Brooks, 1999). In the context of science education, laboratory activities

serve as critical platforms for knowledge construction, allowing students to manipulate materials, observe phenomena, and develop conceptual understanding through direct experience.

Bodner (1986) applied constructivist theory specifically to science laboratory learning, arguing that students learn best when they can connect new experiences to their existing knowledge structures. This theory suggests that inadequate laboratory facilities limit students' opportunities for meaningful knowledge construction, potentially resulting in superficial learning and poor academic performance. The hands-on nature of laboratory work aligns with constructivist emphasis on active learning, making well-equipped laboratories essential for effective science education (Driver et al., 1994).

2.1.2 Experiential Learning Theory

Kolb's (1984) experiential learning theory provides additional theoretical support for the importance of laboratory facilities in science education. The theory proposes a four-stage learning cycle: Concrete experience, reflective observation, abstract conceptualization, and active experimentation. Laboratory activities naturally incorporate all four stages, allowing students to experience phenomena directly, observe and reflect on results, develop theoretical understanding, and test hypotheses through experimentation.

Healey and Jenkins (2000) demonstrated that experiential learning in laboratory settings significantly enhances student engagement and academic achievement in science subjects. When laboratory facilities are inadequate, students cannot fully engage in the experiential learning cycle, potentially compromising their ability to develop deep understanding of scientific concepts. This theoretical perspective emphasizes the critical role of well-equipped laboratories in facilitating meaningful learning experiences.

2.1.3 Social Learning Theory

Bandura's (1977) social learning theory also contributes to understanding the laboratory-performance relationship. The theory emphasizes the importance of modeling, observation, and social interaction in learning processes. Laboratory work typically involves collaborative learning, peer interaction, and demonstration by instructors, all of which are key components of social learning theory.

Tobin and Fraser (1990) found that laboratory environments that support social interaction and collaborative learning lead to improved student outcomes in science education. Inadequate laboratory facilities may limit opportunities for effective social learning, as overcrowded or poorly equipped spaces can hinder collaboration and peer learning. This theoretical framework suggests that laboratory facility adequacy affects not only individual learning but also the social dynamics that contribute to academic success.

2.2 Conceptual Framework

The conceptual framework for this study illustrates the relationship between laboratory facility adequacy and students' academic performance in Integrated Science. The framework identifies three key dimensions of laboratory facility adequacy: equipment adequacy, space adequacy, and maintenance quality. These dimensions are conceptualized as independent variables that collectively influence students' academic performance, which serves as the dependent variable.

Laboratory equipment adequacy encompasses the availability, functionality, modernity, and appropriateness of scientific instruments and materials needed for practical work. According to Johnstone and Wham (1982), adequate equipment provision is fundamental to successful laboratory learning experiences. Equipment adequacy directly affects students' ability to conduct experiments, observe phenomena, and develop practical skills essential for science learning.

Laboratory space adequacy refers to the physical dimensions, layout, and environmental conditions of laboratory facilities. Reid and Shah (2007) emphasized that adequate space allocation is crucial for student safety, effective group work, and optimal learning conditions. Overcrowded laboratories can compromise learning effectiveness and create safety hazards that negatively impact student performance.

Laboratory maintenance quality involves the systematic care, repair, and upkeep of laboratory facilities and equipment. Lunetta et al. (2007) argued that poor maintenance leads to equipment failure, safety concerns, and deteriorating learning conditions. Regular maintenance ensures that laboratory facilities remain functional and conducive to effective learning.

The conceptual framework posits that these three dimensions of laboratory facility adequacy work synergistically to influence students' academic performance. When facilities are adequate across all dimensions, students are more likely to achieve higher academic performance. Conversely, inadequacies in any dimension can negatively impact learning outcomes and academic achievement.

2.3 Empirical Review

2.3.1 Laboratory Facilities and Academic Performance

Extensive empirical research has examined the relationship between laboratory facilities and student academic performance in science education. Hofstein and Lunetta (2004) conducted a comprehensive review of laboratory learning research and found consistent evidence that well-equipped laboratories enhance student achievement in science subjects. Their analysis of multiple studies revealed that students with access to adequate laboratory facilities demonstrated significantly higher performance on both practical and theoretical assessments.

In the Nigerian context, Adeyemi (2008) investigated the relationship between laboratory adequacy and student performance in physics among secondary school students in Ondo State.

The study found a significant positive correlation ($r = 0.72$, $p < 0.01$) between laboratory facility quality and students' achievement in physics. Students in schools with well-equipped laboratories scored 23% higher on average than those in poorly equipped schools. This finding underscores the critical importance of laboratory infrastructure in the Nigerian educational system.

Akpan (2020) examined laboratory facility adequacy in colleges of education across the Niger Delta region of Nigeria. The study revealed that 78% of surveyed institutions had inadequate laboratory equipment, while 65% reported insufficient laboratory space. Furthermore, the research found significant positive correlations between laboratory adequacy scores and students' academic performance in science subjects ($r = 0.68$, $p < 0.01$). These findings highlight the widespread nature of laboratory inadequacies in Nigerian teacher training institutions.

2.3.2 Equipment Adequacy and Learning Outcomes

Research specifically focusing on laboratory equipment adequacy has consistently demonstrated its impact on student learning outcomes. Millar et al. (1999) conducted a longitudinal study involving 2,000 students across 50 schools in the United Kingdom and found that equipment adequacy was the strongest predictor of student performance in practical science assessments. Schools with comprehensive equipment inventories showed 35% higher pass rates in practical examinations compared to those with limited equipment.

Ogunleye (2006) investigated the relationship between chemistry laboratory equipment and student achievement in Lagos State, Nigeria. The study found that schools with adequate equipment had significantly higher mean scores in chemistry examinations ($M = 68.4$, $SD = 12.3$) compared to schools with inadequate equipment ($M = 42.7$, $SD = 10.8$). The effect size of 2.23 indicated a large practical significance, demonstrating the substantial impact of equipment adequacy on student performance.

In the same vein, Uwameiye and Ojikutu (2008) examined equipment adequacy in chemistry laboratories across Edo State colleges of education. The research revealed that institutions with modern, functional equipment had student achievement rates 40% higher than those with obsolete or non-functional equipment. The study also found that equipment adequacy was a stronger predictor of performance than class size or teacher qualifications, emphasizing the critical importance of laboratory infrastructure.

2.3.3 Laboratory Space and Learning Environment

Research on laboratory space adequacy has revealed its significant impact on learning effectiveness and student outcomes. Blosser (1988) analyzed the relationship between laboratory space allocation and student performance across multiple science subjects. The study found that laboratories with adequate space per student (minimum 5 square meters) showed significantly higher achievement levels compared to overcrowded facilities. Students in adequately spaced laboratories also demonstrated better collaborative skills and higher engagement levels.

In the African context, Okafor (2000) investigated laboratory space adequacy in Nigerian universities and found that overcrowded laboratories significantly impaired student learning experiences. The study revealed that laboratories with student-to-space ratios exceeding recommended standards had 28% lower performance rates in practical examinations. Additionally, overcrowded conditions were associated with increased safety incidents and reduced student satisfaction with laboratory experiences.

Again, Eze (2015) examined laboratory space adequacy in Rivers State colleges of education and found significant relationships between space allocation and student performance. Institutions with adequate laboratory space showed higher mean performance scores ($M = 3.24$, $SD = 0.67$) compared to those with inadequate space ($M = 2.78$, $SD = 0.54$). The study also revealed that space adequacy influenced student attitudes toward science subjects, with better-spaced laboratories associated with more positive attitudes.

2.3.4 Maintenance Quality and Laboratory Effectiveness

Research on laboratory maintenance quality has demonstrated its crucial role in sustaining effective learning environments. Fraser and McRobbie (1995) conducted a multi-year study tracking the relationship between maintenance quality and laboratory effectiveness. The research found that laboratories with systematic maintenance programs maintained their effectiveness over time, while those without proper maintenance showed declining performance outcomes. Well-maintained laboratories had equipment availability rates of 95% compared to 67% in poorly maintained facilities.

Okebukola (1986) investigated maintenance practices in Nigerian school laboratories and found significant relationships between maintenance quality and student achievement. Schools with regular maintenance schedules had functional equipment rates of 89% compared to 34% in schools without maintenance programs. The study also revealed that maintenance quality was a significant predictor of student performance ($\beta = 0.43$, $p < 0.01$) even after controlling for other facility factors.

Nworgu (2006) examined maintenance challenges in Nigerian colleges of education and found that poor maintenance culture significantly impaired laboratory effectiveness. The study revealed that institutions with dedicated maintenance personnel and systematic maintenance protocols had 52% higher equipment functionality rates compared to those without proper maintenance systems. These findings highlight the critical importance of maintenance quality in sustaining laboratory effectiveness.

2.3.5 Integrated Science Laboratory Requirements

Research specific to Integrated Science education has emphasized the unique laboratory requirements of this multidisciplinary subject. Bajah (1999) argued that Integrated Science laboratories require diverse equipment and resources to accommodate physics, chemistry, and

biology components. The study found that laboratories designed specifically for Integrated Science showed better learning outcomes compared to those adapted from single-subject laboratories.

Similarly, Umoh (2008) investigated Integrated Science laboratory adequacy in Nigerian colleges of education and found that most institutions lacked the comprehensive equipment inventories needed for effective teaching. The study revealed that only 23% of surveyed institutions had adequate equipment for all three science disciplines. Furthermore, the research found significant positive correlations between equipment comprehensiveness and student performance in Integrated Science ($r = 0.74$, $p < 0.01$).

Likewise, Obioma (2005) examined the challenges of Integrated Science teaching in Nigerian teacher training institutions and identified laboratory inadequacy as a major constraint. The study found that institutions with well-equipped Integrated Science laboratories produced teachers with better practical skills and higher confidence levels. These findings underscore the importance of adequate laboratory facilities in preparing competent Integrated Science teachers.

2.3.6 International Comparative Studies

International research provides additional perspective on laboratory facility impacts across different educational contexts. Lawson (2001) compared laboratory learning outcomes across six countries and found that nations with higher laboratory facility standards showed consistently better science education outcomes. The study revealed that countries investing more than 15% of education budgets in laboratory infrastructure had significantly higher international science assessment scores.

Similarly, Tsai (2003) conducted a comparative study of laboratory facilities in Asian countries and found significant variations in facility adequacy and corresponding differences in student performance. Countries with comprehensive laboratory standards and regular facility assessments showed 28% higher performance rates in international science comparisons. The study emphasized the importance of systematic approaches to laboratory facility development and maintenance.

Furthermore, White (2007) examined laboratory facility impacts across developed and developing countries and found that adequate facilities were essential for science education effectiveness regardless of economic context. However, the study also revealed that developing countries faced greater challenges in maintaining facility adequacy due to resource constraints and infrastructure limitations. These findings highlight the particular importance of strategic planning and resource allocation in developing country contexts.

3.0. Methodology

3.1 Research Design

This study employed a descriptive survey research design to investigate the relationship between laboratory facility adequacy and students' academic performance in Integrated Science. The descriptive survey design was appropriate for this study as it allowed for the collection of data from a large sample of respondents to describe existing conditions and relationships (Creswell, 2014).

3.2 Population and Sample

The population for this study comprised all 480 NCE II students offering Integrated Science at the Federal College of Education (Technical), Omoku, during the 2023/2024 academic session. A sample size of 240 students was selected using systematic random sampling technique, representing 50% of the total population. This sample size was considered adequate based on Krejcie and Morgan's (1970) table for determining sample size.

3.3 Instrumentation

Data were collected using two instruments:

1. **Laboratory Facility Assessment Questionnaire (LFAQ):** A 24-item structured questionnaire designed to assess the adequacy of laboratory equipment, space, and maintenance quality. The instrument used a 4-point Likert scale ranging from "Strongly Agree" (4) to "Strongly Disagree" (1).
2. **Academic Performance Data:** Students' academic performance was measured using their cumulative grade point average (CGPA) in Integrated Science courses obtained from official academic records.

3.4 Validity and Reliability

The instruments were validated by three experts in science education and measurement and evaluation. Their suggestions were incorporated to improve the content validity of the instruments. The reliability of the LFAQ was established through a pilot study involving 30 students not included in the main study. Cronbach's alpha coefficient of 0.87 was obtained, indicating high internal consistency.

3.5 Data Collection Procedure

Data collection was conducted over a period of four weeks. The researchers personally administered the questionnaires to respondents in their respective classrooms. Students' academic performance data were obtained from the institution's academic records office with appropriate permissions.

3.6 Data Analysis

Data were analyzed using both descriptive and inferential statistics. Descriptive statistics including means, standard deviations, and percentages were used to analyze demographic data and describe the variables. Pearson Product-Moment Correlation was used to test the relationships between variables, while t-tests were employed to compare group means. All hypotheses were tested at 0.05 level of significance using SPSS version 25.

4 Results

4.1 Demographic Characteristics of Respondents

Table 1 presents the demographic characteristics of the 240 respondents who participated in the study.

Table 1: Demographic Characteristics of Respondents

Variable	Category	Frequency	Percentage
Gender	Male	132	55.0
	Female	108	45.0
Age Range	18-22 years	164	68.3
	23-27 years	58	24.2
	28-32 years	18	7.5
Academic Level	NCE II	240	100.0
Total		240	100.0

4.2 Laboratory Equipment Adequacy

Table 2 shows the assessment of laboratory equipment adequacy as perceived by students.

Table 2: Assessment of Laboratory Equipment Adequacy

Item	Mean	SD	Interpretation
Available equipment meets practical needs	2.18	0.92	Inadequate
Equipment is modern and functional	1.96	0.87	Inadequate
Sufficient equipment for all students	2.05	0.78	Inadequate
Equipment covers all subject areas	2.34	0.96	Inadequate
Regular equipment replacement	1.89	0.83	Inadequate
Equipment quality is satisfactory	2.12	0.91	Inadequate
Overall Equipment Adequacy	2.09	0.71	Inadequate

Note: Scale: 1.00-1.49 = Very Inadequate; 1.50-2.49 = Inadequate; 2.50-3.49 = Adequate; 3.50-4.00 = Very Adequate

4.3 Laboratory Space Adequacy

Table 3 presents the assessment of laboratory space adequacy.

Table 3: Assessment of Laboratory Space Adequacy

Item	Mean	SD	Interpretation
Laboratory size accommodates all students	2.45	1.02	Inadequate
Adequate working space per student	2.31	0.94	Inadequate
Proper ventilation and lighting	2.67	1.12	Adequate
Storage facilities are sufficient	2.08	0.89	Inadequate
Safety features are adequate	2.23	0.97	Inadequate
Overall layout is functional	2.41	1.05	Inadequate
Overall Space Adequacy	2.36	0.83	Inadequate

4.4 Laboratory Maintenance Quality

Table 4 shows the assessment of laboratory maintenance quality.

Table 4: Assessment of Laboratory Maintenance Quality

Item	Mean	SD	Interpretation
Regular maintenance of equipment	1.87	0.76	Inadequate
Prompt repair of faulty equipment	1.94	0.82	Inadequate
Cleanliness of laboratory facilities	2.56	1.08	Adequate
Availability of maintenance personnel	1.78	0.71	Inadequate
Quality of maintenance services	1.91	0.79	Inadequate
Preventive maintenance programs	1.65	0.68	Inadequate
Overall Maintenance Quality	1.95	0.64	Inadequate

4.5 Students' Academic Performance

Table 5 presents the distribution of students' academic performance in Integrated Science.

Table 5: Distribution of Students' Academic Performance

CGPA Range	Grade	Frequency	Percentage	Mean CGPA
3.50-4.00	First Class	28	11.7	3.72

CGPA Range	Grade	Frequency	Percentage	Mean CGPA
3.00-3.49	Second Class Upper	67	27.9	3.24
2.50-2.99	Second Class Lower	89	37.1	2.74
2.00-2.49	Third Class	56	23.3	2.21
Total		240	100.0	2.85

4.6 Correlation Analysis

Table 6 presents the correlation coefficients between laboratory facility variables and academic performance.

Table 6: Correlation Matrix of Laboratory Facilities and Academic Performance

Variable	1	2	3	4
1. Equipment Adequacy	1.00			
2. Space Adequacy	0.543**	1.00		
3. Maintenance Quality	0.612**	0.487**	1.00	
4. Academic Performance	0.678**	0.592**	0.634**	1.00

*Note: $*p < 0.01$

4.7 Hypothesis Testing

Table 7: Summary of Hypothesis Testing

Hypothesis	r-value	p-value	Decision
H ₀₁ : Equipment Adequacy vs Performance	0.678	0.000	Rejected
H ₀₂ : Space Adequacy vs Performance	0.592	0.000	Rejected
H ₀₃ : Maintenance Quality vs Performance	0.634	0.000	Rejected

4.8 Comparative Analysis

Table 8 compares academic performance between students with adequate and inadequate laboratory facilities.

Table 8: Comparison of Academic Performance by Laboratory Facility Adequacy

Group	N	Mean CGPA	SD	t-value	p-value
Adequate Facilities	89	3.42	0.68	8.234	0.000
Inadequate Facilities	151	2.78	0.54		

5. Discussion of Findings

The findings of this study reveal significant relationships between laboratory facility adequacy and students' academic performance in Integrated Science at the Federal College of Education (Technical), Omoku. The results demonstrate that inadequate laboratory facilities substantially impair student learning outcomes, confirming concerns raised in previous research.

5.1 Laboratory Equipment Adequacy and Academic Performance

The study found a strong positive correlation ($r = 0.678$, $p < 0.01$) between laboratory equipment adequacy and students' academic performance. This finding aligns with research by Hofstein and Lunetta (2014), who established that well-equipped laboratories significantly enhance student learning outcomes in science subjects. The low mean score of 2.09 for equipment adequacy indicates that students perceive the available equipment as inadequate for their learning needs.

The inadequacy of laboratory equipment affects students' ability to conduct meaningful experiments and develop practical skills essential for science teaching. As noted by Abrahams and Millar (2008), hands-on laboratory experiences are crucial for developing conceptual understanding and scientific inquiry skills. When equipment is insufficient or non-functional, students are deprived of these critical learning opportunities, resulting in poor academic performance.

5.2 Laboratory Space Adequacy and Academic Performance

The relationship between laboratory space adequacy and academic performance ($r = 0.592$, $p < 0.01$) was also statistically significant, though slightly weaker than the equipment-performance relationship. The mean score of 2.36 for space adequacy indicates that students perceive the available laboratory space as inadequate for effective learning.

Overcrowded laboratories limit students' ability to work effectively and safely during practical sessions. Research by Bennett (2003) demonstrated that adequate laboratory space is essential for proper group dynamics and individual skill development during practical work. The findings suggest that space constraints at the Federal College of Education (Technical), Omoku, may be compromising the quality of laboratory experiences for students.

5.3 Laboratory Maintenance Quality and Academic Performance

The correlation between laboratory maintenance quality and academic performance ($r = 0.634$, $p < 0.01$) was strong and statistically significant. The low mean score of 1.95 for maintenance quality indicates serious deficiencies in the upkeep of laboratory facilities. This finding is consistent with observations by Okoro and Okoro (2016), who identified poor maintenance culture as a major factor contributing to laboratory inadequacies in Nigerian educational institutions.

Poor maintenance leads to equipment breakdown, safety hazards, and general deterioration of laboratory conditions. Students in poorly maintained laboratories may develop negative attitudes

toward practical work and science learning in general. The significant correlation found in this study underscores the importance of establishing proper maintenance protocols for laboratory facilities.

5.4 Comparative Performance Analysis

The comparative analysis revealed that students with access to adequate laboratory facilities achieved significantly higher academic performance ($M = 3.42$, $SD = 0.68$) compared to those with inadequate facilities ($M = 2.78$, $SD = 0.54$). This substantial difference ($t = 8.234$, $p < 0.001$) demonstrates the practical significance of laboratory adequacy for student success.

The magnitude of this difference suggests that improving laboratory facilities could lead to meaningful improvements in student academic outcomes. This finding supports the theoretical premise that constructivist learning, which emphasizes hands-on experiences, is essential for effective science education (Vygotsky, 1978).

5.5 Implications for Teacher Education

The findings have particular significance for teacher education programs. Students at the Federal College of Education (Technical), Omoku, are future science teachers who will influence countless secondary school students. Their own experiences with inadequate laboratory facilities may affect their confidence and competence in teaching practical science skills.

Research by Abell and Roth (1992) established that teachers' attitudes toward laboratory work are significantly influenced by their own experiences as students. If teacher trainees have limited exposure to quality laboratory experiences, they may perpetuate inadequate science teaching practices in their future careers.

6.0 Implications of the Study

The findings of this study have several important implications for educational policy, institutional management, and science education practice:

6.1 Policy Implications

The study provides empirical evidence for the critical importance of laboratory facility investment in teacher education institutions. Policymakers at federal and state levels should prioritize laboratory infrastructure development as a key component of educational quality improvement initiatives. The significant correlations found between facility adequacy and academic performance justify increased budgetary allocations for laboratory equipment and maintenance.

Educational policies should establish minimum standards for laboratory facilities in teacher training institutions, with regular monitoring and evaluation mechanisms to ensure compliance. The study's findings support the need for mandatory laboratory facility assessments as part of institutional accreditation processes.

6.2 Institutional Implications

For the Federal College of Education (Technical), Omoku, the findings highlight the urgent need for comprehensive laboratory facility upgrades. The institution's management should develop strategic plans for equipment procurement, space expansion, and maintenance system improvements. Investment in laboratory facilities should be viewed as an essential component of institutional development rather than an optional enhancement.

The study results also suggest the need for partnerships with government agencies, international organizations, and private sector entities to secure funding for laboratory improvements. Institutional policies should prioritize laboratory facility development in budget allocations and long-term planning initiatives.

6.3 Pedagogical Implications

The findings underscore the importance of adapting teaching methodologies to maximize learning outcomes despite facility limitations. Faculty members should be trained in innovative approaches to practical science teaching that can partially compensate for equipment inadequacies. However, these adaptations should be viewed as temporary measures while working toward comprehensive facility improvements.

The study also highlights the need for staff development programs focused on laboratory management, equipment maintenance, and safety protocols. Proper training of laboratory technicians and academic staff is essential for maximizing the utility of available facilities.

6.4 Research Implications

This study contributes to the growing body of research on infrastructure-performance relationships in educational settings. The findings provide empirical support for theoretical frameworks emphasizing the importance of physical learning environments in academic achievement. Future research should explore specific mechanisms through which laboratory inadequacies affect learning outcomes and investigate intervention strategies for addressing these challenges.

The study's methodology and instruments can be adapted for similar investigations in other educational contexts, contributing to comparative research on laboratory facility impacts across different institutions and regions.

7. Conclusion

This study has demonstrated a significant impact of inadequate laboratory facilities on students' academic performance in Integrated Science at the Federal College of Education (Technical), Omoku, Rivers State. The strong positive correlations found between laboratory equipment adequacy ($r = 0.678$), space adequacy ($r = 0.592$), maintenance quality ($r = 0.634$), and academic performance provide compelling evidence for the critical importance of well-equipped laboratory facilities in science education.

The findings reveal that students in the institution face substantial challenges due to inadequate laboratory equipment, insufficient space, and poor maintenance quality. These deficiencies significantly impair their academic performance, with students having access to adequate facilities achieving substantially higher grades than their counterparts with inadequate facilities. The study's results align with international research findings and theoretical frameworks emphasizing the importance of hands-on learning experiences in science education.

The implications of these findings extend beyond individual student performance to encompass broader concerns about teacher preparation quality and the future of science education in Nigeria. As these students are future science teachers, their own experiences with inadequate laboratory facilities may perpetuate cycles of poor science education in secondary schools.

The comprehensive recommendations proposed in this study provide a roadmap for addressing laboratory facility challenges through coordinated efforts involving institutional management, government agencies, and international partners. Implementation of these recommendations requires sustained commitment and adequate resource allocation to ensure meaningful improvements in laboratory infrastructure.

The urgency of addressing laboratory facility inadequacies cannot be overstated, given their significant impact on student learning outcomes and the broader implications for science education quality in Nigeria. This study provides empirical evidence to support policy decisions and resource allocation strategies aimed at improving educational infrastructure in teacher training institutions.

8. Recommendations

Based on the findings of this study, the following recommendations are proposed:

1. The Federal College of Education (Technical), Omoku should immediately establish a comprehensive laboratory improvement fund to procure modern equipment and expand laboratory spaces to meet current educational standards and student enrollment demands.
2. The institution should develop and implement a structured preventive maintenance program for all laboratory equipment, including the employment of qualified technicians and establishment of regular maintenance schedules to ensure optimal equipment functionality.
3. The Federal Ministry of Education should increase budgetary allocations specifically for laboratory facility development in colleges of education, with annual assessments to monitor implementation progress and ensure sustainable improvements.
4. The college administration should establish partnerships with international organizations, donor agencies, and private sector companies to secure additional funding and equipment donations for laboratory facility enhancement and modernization programs.
5. The institution should implement a laboratory facility utilization optimization program that includes scheduling systems, equipment sharing protocols, and space management strategies to maximize the use of existing resources while facility upgrades are ongoing.

6. The Rivers State Government should provide special intervention funds for laboratory infrastructure development in state educational institutions, recognizing the critical role of well-equipped laboratories in producing competent science teachers.
7. The college should establish a mandatory laboratory safety and maintenance training program for all academic staff, laboratory technicians, and students to ensure proper equipment handling, safety protocol adherence, and facility preservation.
8. The institution should develop alternative practical teaching strategies and simulation-based learning approaches to complement traditional laboratory work while addressing equipment shortages and space limitations through innovative pedagogical methods.
9. The college should create a laboratory facility monitoring and evaluation system that includes regular assessments, student feedback mechanisms, and performance tracking to ensure continuous improvement and accountability in facility management.
10. The Federal College of Education (Technical), Omoku should advocate for policy changes that mandate minimum laboratory facility standards for teacher training institutions, including specific equipment requirements, space allocations, and maintenance protocols to ensure consistent educational quality.

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