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AN EVALUATION OF THE STATE OF SCIENCE LABORATORIES IN PORT HARCOURT POLYTECHNIC

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Abstract

This study evaluates the current state of science laboratories in Port Harcourt Polytechnic, Rivers State, Nigeria. The research examined laboratory infrastructure, equipment availability, safety measures, and their impact on academic performance. A mixed-methods approach was employed, involving surveys of 150 students and 25 faculty members, alongside physical inspections of 12 science laboratories. Results revealed significant deficiencies in equipment maintenance (68% of equipment non-functional), inadequate safety protocols (only 42% compliance rate), and poor infrastructure conditions affecting 75% of laboratories. The study found a negative correlation ($r = -0.67$, $p < 0.01$) between laboratory conditions and student academic performance. Recommendations include immediate infrastructure upgrades, establishment of maintenance protocols, enhanced safety training, and increased funding allocation for laboratory development.

Keywords: ***Science Laboratories, Polytechnic Education, Infrastructure Evaluation, Academic Performance, Technical Education***

Introduction

Science laboratories serve as the cornerstone of practical education in polytechnic institutions, providing students with hands-on experience essential for developing technical competencies (Adeyemi & Adeyinka, 2023). The quality and state of laboratory facilities significantly influence the effectiveness of science education and the preparation of graduates for industrial and technological advancement (Okoro et al., 2022). In Nigeria's educational landscape, polytechnics play a crucial role in producing middle-level manpower required for national development, making the evaluation of their laboratory facilities paramount to educational quality assurance (Nwankwo & Okafor, 2023).

Port Harcourt Polytechnic, established in 1989, has been a leading institution in technical education within the Niger Delta region of Nigeria. The institution offers various science and technology programs, including Engineering Technology, Applied Sciences, and Environmental Technology (Federal Ministry of Education, 2022). However, like many Nigerian tertiary institutions, the polytechnic faces numerous challenges in maintaining adequate laboratory facilities due to funding constraints, rapid technological changes, and increasing student enrollment (Adebayo & Williams, 2023).

The significance of well-equipped and properly maintained science laboratories cannot be overstated in polytechnic education. Research has consistently demonstrated that laboratory experiences enhance student understanding of scientific concepts, develop practical skills, and improve problem-solving abilities (Johnson & Martinez, 2023). Furthermore, the state of

laboratory facilities directly impacts institutional accreditation, graduate employability, and the institution's reputation in the educational sector (Thompson et al., 2022).

Previous studies have highlighted various challenges facing science laboratories in Nigerian polytechnics, including inadequate funding, poor maintenance culture, lack of skilled technical staff, and insufficient safety measures (Okafor & Eze, 2023). These challenges have resulted in suboptimal learning environments that fail to meet international standards and industry requirements (Adeleke & Bakare, 2022). The need for comprehensive evaluation of laboratory facilities has become increasingly urgent as institutions strive to improve educational quality and meet accreditation standards.

International best practices in laboratory management emphasize the importance of regular evaluation and continuous improvement of laboratory facilities (Smith & Anderson, 2023). The World Health Organization (WHO) and UNESCO have established guidelines for laboratory standards that serve as benchmarks for educational institutions globally (UNESCO, 2022). These standards encompass infrastructure quality, equipment functionality, safety protocols, and human resource capacity (WHO, 2023).

Statement of the Problem

Despite the critical importance of science laboratories in polytechnic education, there exists a significant gap in systematic evaluation of laboratory conditions in Nigerian polytechnics, particularly at Port Harcourt Polytechnic. Preliminary observations and anecdotal reports suggest that science laboratories at the institution are plagued with numerous challenges that may be compromising the quality of education provided to students (Ogbonna & Ikechukwu, 2023).

The deteriorating state of laboratory infrastructure has been a persistent concern among faculty members and students. Reports indicate frequent equipment breakdowns, inadequate safety measures, insufficient laboratory space, and poor maintenance practices (Chukwu & Daniel, 2022). These conditions not only affect the quality of practical training but also pose safety risks to users and may result in poor academic outcomes for students.

Furthermore, the rapid advancement in technology and changes in industry requirements demand that polytechnic laboratories remain current and relevant. However, limited financial resources and competing institutional priorities have resulted in outdated equipment and facilities that fail to meet contemporary educational and industry standards (Okoye & Nnamdi, 2023). This situation has implications for graduate employability and the institution's ability to contribute effectively to national technological development.

The lack of comprehensive data on the actual state of science laboratories at Port Harcourt Polytechnic has hindered evidence-based decision-making regarding laboratory improvement initiatives. Without systematic evaluation, it becomes difficult for institutional management to prioritize interventions, allocate resources effectively, and develop strategic plans for laboratory enhancement (Udoh & Akpan, 2022).

Objectives of the Study

The study aims to achieve the following specific objectives:

1. To assess the current physical condition and infrastructure adequacy of science laboratories in Port Harcourt Polytechnic.
2. To evaluate the availability, functionality, and maintenance status of laboratory equipment and instruments in the science departments.
3. To examine the implementation and effectiveness of safety protocols and measures in the science laboratories.

Research Questions

Based on the stated objectives, this study seeks to answer the following research questions:

1. What is the current state of physical infrastructure and space adequacy in the science laboratories of Port Harcourt Polytechnic?
2. To what extent are laboratory equipment and instruments available, functional, and properly maintained in the science departments?
3. How effectively are safety protocols and measures implemented and maintained in the science laboratories?

Literature Review

The evaluation of science laboratory facilities in educational institutions has been a subject of extensive research globally. Laboratory quality assessment frameworks typically encompass multiple dimensions including infrastructure, equipment, safety, human resources, and management systems (Roberts & Clark, 2023). These frameworks provide comprehensive approaches to understanding laboratory effectiveness and identifying areas for improvement.

Infrastructure adequacy represents a fundamental aspect of laboratory evaluation. Research by Williams et al. (2022) demonstrated that physical laboratory conditions significantly influence student engagement and learning outcomes in science education. Key infrastructure elements include adequate space allocation, proper ventilation systems, reliable utilities supply, and appropriate furniture and fittings (Garcia & Lopez, 2023). Studies have shown that overcrowded laboratories with poor infrastructure negatively impact both teaching effectiveness and student safety (Brown & Davis, 2022).

Equipment availability and functionality constitute another critical dimension of laboratory evaluation. Kumar and Patel (2023) found that institutions with well-maintained and modern equipment recorded higher student satisfaction rates and better academic performance compared to those with outdated or non-functional equipment. The study emphasized the importance of regular equipment calibration, preventive maintenance, and timely replacement of obsolete instruments.

Safety considerations in science laboratories have gained increased attention following various laboratory accidents reported in educational institutions worldwide (Miller & Johnson, 2023). Effective safety management requires implementation of comprehensive safety protocols, provision of personal protective equipment, regular safety training, and establishment of emergency response procedures (Taylor & Wilson, 2022). Research has shown that institutions with robust safety cultures experience fewer accidents and create more conducive learning environments.

In the Nigerian context, several studies have examined laboratory conditions in tertiary institutions. Akinola and Ogundipe (2023) conducted a comparative study of laboratory facilities in federal and state polytechnics, revealing significant disparities in resource allocation and facility quality. The study identified funding inadequacy, poor maintenance culture, and lack of technical expertise as primary challenges affecting laboratory development in Nigerian polytechnics.

Similarly, Emeka and Chioma (2022) investigated the relationship between laboratory conditions and student academic performance in science courses. Their findings revealed a strong positive correlation between laboratory quality and student achievement, emphasizing the need for institutional investment in laboratory improvement. The study recommended regular facility audits, increased budgetary allocation, and capacity building for laboratory personnel.

Methodology

This study employed a mixed-methods research design combining quantitative and qualitative approaches to provide comprehensive evaluation of science laboratories at Port Harcourt Polytechnic. The research was conducted over a six-month period from January to June 2024.

Study Population and Sampling

The study population comprised all science departments in Port Harcourt Polytechnic, including Applied Sciences, Engineering Technology, and Environmental Technology departments. A total of 12 science laboratories were selected using purposive sampling technique, representing laboratories from each science department. The study involved 150 students randomly selected from various science programs and 25 faculty members purposively selected based on their laboratory teaching experience.

Data Collection Instruments

Multiple data collection instruments were employed to ensure comprehensive evaluation:

1. **Laboratory Assessment Checklist**: A structured checklist was developed based on international laboratory standards to evaluate physical infrastructure, equipment status, and safety measures.

2. **Student Questionnaire**: A 40-item questionnaire was administered to students to assess their perceptions of laboratory conditions and their impact on learning experiences.

3. **Faculty Interview Guide**: Semi-structured interviews were conducted with faculty members to gather detailed insights on laboratory challenges and improvement needs.
4. **Direct Observation Protocol**: Systematic observations were conducted to document actual laboratory conditions and practices.

Data Collection Procedure

Data collection was conducted in three phases:

Phase 1: Physical inspection of all 12 selected laboratories using the assessment checklist. This involved detailed examination of infrastructure elements, equipment inventory, and safety features.

Phase 2: Administration of questionnaires to students during regular class sessions with prior consent from department heads and individual participants.

Phase 3: Conduct of face-to-face interviews with faculty members and direct observations of laboratory sessions to capture actual usage patterns and challenges.

Data Analysis

Quantitative data from questionnaires and checklists were analyzed using Statistical Package for Social Sciences (SPSS) version 26. Descriptive statistics including frequencies, percentages, means, and standard deviations were computed. Chi-square tests and correlation analyses were performed to examine relationships between variables. Qualitative data from interviews and observations were analyzed using thematic analysis approach to identify key themes and patterns.

Results

Research Question 1: Physical Infrastructure and Space Adequacy

The assessment of physical infrastructure revealed significant deficiencies across the science laboratories. Table 1 presents the infrastructure assessment results.

Table 1: Infrastructure Assessment Results (N=12 laboratories)

Infrastructure Element	Excellent	Good	Fair	Poor	Very Poor
Laboratory Space	0 (0%)	2 (17%)	3 (25%)	5 (42%)	2 (17%)
Ventilation System	1 (8%)	2 (17%)	2 (17%)	4 (33%)	3 (25%)
Lighting Adequacy	2 (17%)	3 (25%)	3 (25%)	3 (25%)	1 (8%)
Electrical Installation	0 (0%)	3 (25%)	4 (33%)	3 (25%)	2 (17%)
Water Supply	1 (8%)	1 (8%)	2 (17%)	4 (33%)	4 (33%)

Infrastructure Element	Excellent	Good	Fair	Poor	Very Poor
Drainage System	0 (0%)	2 (17%)	3 (25%)	4 (33%)	3 (25%)
Floor Condition	1 (8%)	4 (33%)	3 (25%)	3 (25%)	1 (8%)
Wall Condition	2 (17%)	3 (25%)	4 (33%)	2 (17%)	1 (8%)
Ceiling Condition	1 (8%)	3 (25%)	4 (33%)	3 (25%)	1 (8%)
Furniture Adequacy	0 (0%)	1 (8%)	4 (33%)	5 (42%)	2 (17%)

The results indicate that 75% of laboratories (9 out of 12) have inadequate space allocation, with overcrowding being a major concern. Ventilation systems were found to be poor or very poor in 58% of laboratories, creating uncomfortable working conditions. Water supply systems showed the most severe deficiencies, with 66% of laboratories having poor or very poor water supply reliability.

Student perceptions of infrastructure adequacy are presented in Table 2.

Table 2: Student Perceptions of Laboratory Infrastructure (N=150)

Infrastructure Aspect	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Laboratory space is adequate	8 (5.3%)	22 (14.7%)	18 (12%)	67 (44.7%)	35 (23.3%)
Ventilation is satisfactory	12 (8%)	28 (18.7%)	25 (16.7%)	54 (36%)	31 (20.7%)
Lighting is sufficient	18 (12%)	42 (28%)	31 (20.7%)	41 (27.3%)	18 (12%)
Furniture is adequate	6 (4%)	19 (12.7%)	22 (14.7%)	68 (45.3%)	35 (23.3%)
Overall infrastructure quality	5 (3.3%)	15 (10%)	28 (18.7%)	72 (48%)	30 (20%)

The student survey revealed that 68% of respondents disagreed or strongly disagreed that laboratory space was adequate for practical sessions. Similarly, 68.6% expressed dissatisfaction with furniture adequacy, and 68% rated overall infrastructure quality as poor.

Equipment Availability and Functionality

The equipment assessment revealed concerning patterns regarding availability and functionality across science laboratories. Table 3 summarizes the equipment status findings.

Table 3: Equipment Status Assessment (N=12 laboratories)

Equipment Category	Total Units	Functional	Non-Functional	Obsolete	Maintenance Needed
Microscopes	124	42 (34%)	35 (28%)	28 (23%)	19 (15%)
Analytical Balances	36	18 (50%)	8 (22%)	6 (17%)	4 (11%)
Spectrophotometers	18	6 (33%)	7 (39%)	3 (17%)	2 (11%)
Centrifuges	24	9 (38%)	8 (33%)	4 (17%)	3 (13%)
pH Meters	42	15 (36%)	12 (29%)	9 (21%)	6 (14%)
Incubators	15	5 (33%)	6 (40%)	3 (20%)	1 (7%)
Fume Hoods	28	8 (29%)	12 (43%)	5 (18%)	3 (11%)
Safety Equipment	156	68 (44%)	45 (29%)	28 (18%)	15 (10%)

Overall equipment functionality stood at only 32%, indicating that approximately two-thirds of laboratory equipment was either non-functional, obsolete, or required immediate maintenance. This severely limited the scope and quality of practical exercises that could be conducted.

Faculty perceptions of equipment adequacy are presented in Table 4.

Table 4: Faculty Assessment of Equipment Status (N=25)

Equipment Aspect	Excellent	Good	Fair	Poor	Very Poor
Equipment Availability	0 (0%)	3 (12%)	6 (24%)	11 (44%)	5 (20%)
Equipment Functionality	1 (4%)	2 (8%)	4 (16%)	13 (52%)	5 (20%)
Equipment Currency	0 (0%)	1 (4%)	5 (20%)	12 (48%)	7 (28%)
Maintenance Frequency	0 (0%)	2 (8%)	3 (12%)	14 (56%)	6 (24%)
Technical Support	0 (0%)	1 (4%)	4 (16%)	11 (44%)	9 (36%)

Faculty responses confirmed the equipment challenges, with 72% rating equipment functionality as poor or very poor. Maintenance frequency was particularly problematic, with 80% of faculty indicating inadequate maintenance practices.

Safety Protocols and Implementation

The safety assessment revealed significant gaps in safety protocol implementation and compliance. Table 5 presents the safety evaluation results.

Table 5: Safety Protocol Assessment (N=12 laboratories)

Safety Element	Present & Functional	Present but Non-Functional	Absent	Compliance Rate
Fire Extinguishers	8 (67%)	2 (17%)	2 (17%)	67%
First Aid Kits	7 (58%)	3 (25%)	2 (17%)	58%
Emergency Exits	10 (83%)	1 (8%)	1 (8%)	83%
Safety Showers	2 (17%)	3 (25%)	7 (58%)	17%
Eye Wash Stations	3 (25%)	2 (17%)	7 (58%)	25%
Fume Hoods	4 (33%)	5 (42%)	3 (25%)	33%
Personal Protective Equipment	5 (42%)	2 (17%)	5 (42%)	42%
Safety Signage	6 (50%)	1 (8%)	5 (42%)	50%
Chemical Storage	4 (33%)	3 (25%)	5 (42%)	33%
Waste Disposal Systems	3 (25%)	2 (17%)	7 (58%)	25%

Overall safety compliance rate was calculated at 42%, indicating significant safety deficiencies across the laboratories. Critical safety equipment such as safety showers and eye wash stations were absent in 58% of laboratories, while proper chemical storage and waste disposal systems were lacking in most facilities.

Student safety awareness and training status are shown in Table 6.

Table 6: Student Safety Training and Awareness (N=150)

Safety Aspect	Yes	No	Not Sure
Received laboratory safety training	48 (32%)	87 (58%)	15 (10%)
Familiar with emergency procedures	42 (28%)	93 (62%)	15 (10%)
Know location of safety equipment	61 (40.7%)	76 (50.7%)	13 (8.7%)
Experienced safety incidents	23 (15.3%)	119 (79.3%)	8 (5.3%)
Feel safe during laboratory sessions	67 (44.7%)	61 (40.7%)	22 (14.7%)

The survey revealed that 58% of students had not received adequate safety training, and 62% were unfamiliar with emergency procedures. Concerning, 15.3% of students reported experiencing safety incidents during laboratory sessions.

Correlation Analysis

Statistical analysis revealed significant correlations between laboratory conditions and academic performance. Table 7 presents the correlation matrix.

Table 7: Correlation Analysis between Laboratory Conditions and Academic Performance

Variables	Academic Performance	Infrastructure Quality	Equipment Status	Safety Implementation
Academic Performance	1.000	0.672**	0.543**	0.391*
Infrastructure Quality	0.672**	1.000	0.487**	0.356*
Equipment Status	0.543**	0.487**	1.000	0.298*
Safety Implementation	0.391*	0.356*	0.298*	1.000

**p < 0.05, **p < 0.01

The analysis revealed strong positive correlations between laboratory conditions and student academic performance. Infrastructure quality showed the strongest correlation with academic

performance ($r = 0.672$, $p < 0.01$), followed by equipment status ($r = 0.543$, $p < 0.01$) and safety implementation ($r = 0.391$, $p < 0.05$).

Discussion

The findings of this study reveal significant deficiencies in the state of science laboratories at Port Harcourt Polytechnic, consistent with challenges reported in other Nigerian tertiary institutions. The poor infrastructure conditions, with 75% of laboratories having inadequate space and ventilation problems, align with findings by Adeyemi and Adeyinka (2023) who reported similar infrastructure challenges in Nigerian polytechnics. The overcrowding observed in most laboratories not only compromises the quality of practical education but also poses safety risks to users, supporting concerns raised by Brown and Davis (2022) regarding the impact of inadequate space on laboratory safety.

The equipment functionality rate of only 32% represents a critical challenge that severely limits the effectiveness of practical training. This finding is consistent with Kumar and Patel's (2023) observation that equipment availability and functionality are fundamental determinants of laboratory effectiveness. The high proportion of obsolete equipment (average 19% across categories) reflects the long-standing challenges of inadequate funding and poor maintenance culture in Nigerian educational institutions, as documented by Okafor and Eze (2023).

The safety protocol implementation rate of 42% is particularly concerning given the inherent risks associated with science laboratory activities. The absence of critical safety equipment such as safety showers and eye wash stations in majority of laboratories, combined with inadequate safety training for 58% of students, creates an environment prone to accidents. This situation contradicts international best practices as outlined by WHO (2023) and UNESCO (2022), which emphasize comprehensive safety management as a non-negotiable requirement for educational laboratories.

The strong positive correlation ($r = 0.672$, $p < 0.01$) between infrastructure quality and academic performance provides empirical evidence supporting the theoretical framework linking laboratory conditions to educational outcomes. This finding reinforces previous research by Emeka and Chioma (2022) who demonstrated similar relationships in Nigerian tertiary institutions. The correlation suggests that improvements in laboratory conditions could yield significant benefits in terms of student academic achievement.

The maintenance challenges identified in this study reflect broader systemic issues in Nigerian educational institutions. The absence of systematic maintenance protocols and limited technical support capacity, as reported by 80% of faculty, indicate the need for comprehensive institutional reforms. These findings support recommendations by Adeleke and Bakare (2022) for establishing professional maintenance systems in educational institutions.

The low level of safety awareness among students, with 62% unfamiliar with emergency procedures, highlights the need for mandatory safety training programs. The fact that 15.3% of students reported experiencing safety incidents during laboratory sessions underscores the

urgency of implementing comprehensive safety measures. This situation is particularly concerning given the potential for serious injuries in science laboratories, as documented in international safety literature (Miller & Johnson, 2023).

The equipment obsolescence rate averaging 19% across categories indicates the need for systematic equipment replacement programs. The rapid pace of technological advancement in scientific instrumentation means that polytechnic institutions must continuously update their equipment to remain relevant and provide graduates with current technical skills (Roberts & Clark, 2023).

Conclusion

This comprehensive evaluation of science laboratories at Port Harcourt Polytechnic reveals significant deficiencies across all assessed dimensions: infrastructure, equipment, and safety protocols. The study establishes clear evidence of suboptimal laboratory conditions that compromise the quality of science education and pose safety risks to users. With only 32% of equipment functional, 42% safety compliance rate, and 75% of laboratories having inadequate infrastructure, the institution faces substantial challenges in meeting educational and safety standards.

The strong correlation between laboratory conditions and academic performance ($r = 0.672$, $p < 0.01$) provides compelling evidence that improving laboratory facilities could significantly enhance educational outcomes. The findings underscore the urgent need for comprehensive laboratory improvement initiatives encompassing infrastructure rehabilitation, equipment replacement and maintenance, and safety protocol implementation.

The study contributes valuable empirical data to the limited research on laboratory evaluation in Nigerian polytechnics and provides a framework for systematic assessment that could be adopted by other institutions. The findings have important implications for institutional planning, resource allocation, and quality assurance in polytechnic education.

Recommendations

1. The institution should immediately establish a comprehensive laboratory infrastructure rehabilitation program with dedicated funding allocation of at least 15% of annual budget to address the critical deficiencies in space, ventilation, utilities, and furniture across all science laboratories.

2. A systematic equipment replacement and maintenance program should be implemented with annual equipment audits, preventive maintenance schedules, and partnerships with equipment manufacturers to ensure optimal functionality and currency of laboratory instruments.

3. Mandatory comprehensive safety training programs should be instituted for all laboratory users, including students, faculty, and technical staff, with regular refresher sessions and

safety competency assessments to ensure compliance with international laboratory safety standards.

4. The institution should recruit and train dedicated laboratory technicians for each science department to provide technical support, equipment maintenance, and safety oversight to improve laboratory operations and reduce equipment downtime.
5. A centralized laboratory management information system should be developed to track equipment status, maintenance schedules, safety incidents, and utilization patterns to enable data-driven decision making for laboratory improvement initiatives.
6. Strategic partnerships should be established with industries, research institutions, and international organizations to access funding, equipment donations, and technical expertise for laboratory development and capacity building programs.
7. The institution should implement a phased laboratory renovation program starting with the most critical laboratories identified in this study, prioritizing safety installations, infrastructure upgrades, and space optimization to create conducive learning environments.
8. A laboratory safety committee should be established with representation from all science departments to develop safety protocols, conduct regular safety inspections, investigate incidents, and ensure continuous improvement of safety practices across all laboratories.
9. Student laboratory fees should be introduced or increased to generate dedicated revenue for laboratory maintenance and equipment replacement, with transparent utilization reporting to ensure funds are appropriately directed toward laboratory improvement initiatives.
10. The institution should pursue international laboratory accreditation standards such as ISO 17025 to benchmark laboratory quality, attract research collaborations, and enhance institutional reputation in the global academic community.

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