Laboratory Safety Practices and Accident Avoidance among Secondary School Physics Students in Calabar Municipality, Cross River State, Nigeria

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DOI: https://doi.org/10.67487/jprss.v2i3.257

Citation: Ayeshung, R. I. (2026). Laboratory Safety Practices and Accident Avoidance among Secondary School Physics Students in Calabar Municipality, Cross River State, Nigeria. *International Journal of Public Relations and Social Sciences, 2(3)*

Abstract

The study investigated the influence of laboratory safety practices on accident avoidance among secondary school physics students in Calabar Municipality, Cross River State, Nigeria. The study focused on two safety practices: the use of personal protective equipment and safety awareness. The study was guided by two research questions and two research hypotheses. A descriptive survey research design was adopted. The population of the study was 2,623 physics students from the study area. A simple random sampling technique was used to select 347 respondents, and the sample size was determined using Taro Yemane's formula $n=N/1+N(e)^2$. Data were collected using a structured questionnaire titled Laboratory Safety Practices Questionnaire (LSPQ). The questionnaire adopted a four-point Likert scale consisting of Strongly Agree, Agree, Disagree, and Strongly Disagree. The instrument was validated through face and content validation by experts in science education. A reliability test was conducted, and the instrument yielded a reliability coefficient of 0.81 - 0.88 using Cronbach's alpha. The data collected were analyzed using simple linear regression. The results showed that the use of personal protective equipment significantly influenced accident avoidance in physics laboratories. It was therefore recommended that physics teachers should emphasize laboratory safety procedures and ensure that students comply with established laboratory safety rules.

Keywords: laboratory safety, personal protective equipment, physics, safety awareness

Introduction

Physics, alongside Biology and Chemistry, is one of the core science subjects taught in secondary schools. Physics application deals with every day's and occupies an important position in science and technology because it contributes significantly to scientific innovation, technological advancement, and national development. The teaching of Physics involves both practical and theoretical components, with practical aspect helping students to understand, verify and apply scientific concepts learned in theory. Physics practical activities are usually carried out in laboratories where students interact directly with scientific apparatus and material in order to develop manipulative skills, problem-solving abilities and scientific attitudes (Sesay et al, 2022).

The use of the laboratory for practical Physics entails ensuring the safety of both students and teachers. Laboratory users cannot be too careful, as they may be exposed to hazards at any time during experiments. Effective teaching of science, according to Nwune et al. (2023), depends largely on strict adherence to laboratory safety measures, which help in preventing accidents during experiments. Physics practical lessons are conducted in laboratories equipped with apparatus for students to handle and manipulate for effective learning (Ayeshung, 2020).

A science laboratory is a place where basic experimental skills are learned through the performance of prescribed experiments (Shrivastava, 2017). It provides a controlled environment equipped with apparatus and facilities that enable students and teachers to carry out practical activities and observe natural phenomena (Anaekwe & Nweke, 2021). Through laboratory activities, students develop practical skills and gain a deeper understanding of scientific concepts. Laboratory safety refers to the set of practices and procedures implemented during practical sessions to prevent accidents and injuries. These safety measures apply not only to students and teachers but also to laboratory attendants who assist in setting up equipment and materials.

Safety, according to Omeije and Omeje (2014) is a fundamental requirement in all laboratories, affecting staff, students, and visitors within the school environment. It is not a complex concept that requires specialized expertise or significant financial investment but can be integrated into existing school processes (Omeije & Omeje, 2014). Safety in the laboratory requires an understanding of safety protocols to ensure the well-being of students and a conducive learning environment. Failure to adhere to proper safety measures can result in hazards for all individuals present. Strict adherence to safety rules, practices, and precautions facilitates safe laboratory activities.

Accidents in physics laboratories may arise from several sources, including explosive materials, flammable substances, and electrical hazards. Safety practices involve measures taken to prevent danger in the physics laboratory (Anaekwe & Nweke, 2021). Accidents are caused by various unstable factors that may lead to injuries, loss of life, property damage, and environmental harm (Chao et al. (2023)). Insufficient safety knowledge and lack of safety culture among laboratory users are major causes of unsafe practices. To effectively utilize laboratory procedures, there is a need for adequate knowledge and proper implementation of laboratory skills to prevent accidents that may hinder effective laboratory use and limit the full realization of its potential in science development (Nwune et al. (2023)). Prioritizing laboratory safety practices establishes a foundation for responsible conduct during physics practical. Consequently, instilling a culture of safety among students when they are in the laboratory not only protects lives but also creates a conducive learning environment.

Personal Protective Equipment (PPE) consists of tools used in the laboratory to reduce or prevent accidents and injuries among students, teachers, and laboratory attendants during experiments. These include safety boots, helmets, hand gloves, and eye goggles, among others. PPE refers to specialized protective clothing or equipment worn by individuals for safety (Amer, 2023). Tarlengco (2024) defines PPE as protective equipment for the eyes, head, ears, hands, respiratory system, body, and feet. Laboratory coats, for example, protect students from exposure to hazards and reduce the risk of injuries in physics laboratories.

Safety awareness refers to the consciousness and understanding of potential risks and the measures required to prevent harm. Laboratory safety awareness involves rules and guidelines that students follow to avoid accidents. These include proper handling of laboratory apparatus and correct procedures for conducting experiments. Safety awareness is a learned behaviour that can be incorporated into instructional practices (Shrivastava, 2017). Conducting experiments requires care, patience, and skill, and adherence to safety practices helps ensure an accident-free laboratory environment.

Despite the importance of laboratory safety, accidents continue to occur in school laboratories, indicating a persistent safety challenge in secondary school science education. These incidents are often attributed to inadequate safety practices, low levels of safety awareness, and poor compliance with established laboratory safety rules. In many Nigerian secondary schools, there is limited emphasis on structured laboratory safety training, and students are frequently exposed to laboratory risks without adequate preparation or supervision. Although previous

studies have examined aspects of laboratory safety, there is limited empirical evidence on the combined influence of personal protective equipment and safety awareness on accident avoidance among secondary school physics students, particularly in Calabar Municipality. This gap in the literature necessitates the present study.

Empirical studies

Bello (2012) examined the availability and utilization of physics laboratory equipment in the teaching and learning of physics in senior secondary schools in Nigeria using a descriptive survey design. The study involved a sample of 900 students selected through random sampling and 50 teachers purposively selected from 45 secondary schools in the South-West region. Data were collected using instruments including the Physics Laboratory Equipment Questionnaire (PLEQ), a checklist of physics equipment, and a Physics Achievement Test (PAT), with a reliability coefficient of 0.72. The findings revealed that the optimal utilization of laboratory equipment significantly enhances the teaching and learning of physics. It was also observed that federal schools had more adequately utilized equipment compared to private and public schools. The study implies that while the availability of laboratory equipment is essential, its effective and safe utilization is critical, thereby underscoring the importance of safety practices such as the use of personal protective equipment during laboratory activities.

Anaekwe and Nweke (2021) investigated the types of accidents and safety practices in physics laboratories in secondary schools in Anambra State using a descriptive survey research design. The study was guided by five research questions and two null hypotheses, with a population of 181 SS3 physics students and a sample of 130 students selected through simple random sampling. Data were collected using a structured questionnaire validated by experts, and a reliability index of 0.98 was obtained using the Pearson Product Moment Correlation coefficient. Mean, standard deviation, and t-test statistics were used for data analysis. The findings indicated that accidents such as cuts, electric shocks, and heat-related injuries were largely caused by improper handling of equipment and poor adherence to safety measures. Inadequate safety equipment was also identified as a major cause of laboratory accidents. The study implies that adherence to safety practices and provision of adequate safety facilities are essential in preventing accidents in physics laboratories.

Ponferrada et al. (2017) examined students' safety awareness in physics laboratories using a survey research design in the Philippines. The study involved

324 randomly selected students across different practical areas, including Mechanics and Heat, as well as Electricity and Magnetism. Data were collected using a modified questionnaire, and the independent t-test was used for analysis. The findings showed that students demonstrated a positive level of safety awareness and had favourable perceptions of safety measures in reducing laboratory risks. The study implies that although students may possess a basic level of safety awareness, continuous reinforcement and practical application of safety rules are necessary to ensure effective accident prevention in laboratory settings.

More recent empirical evidence further reinforces the importance of laboratory safety awareness and practices. Caymaz (2021) examined secondary school students' knowledge and perceptions of laboratory safety using a survey design involving 136 students. Data were collected through open-ended questionnaires and analyzed using content analysis. The findings indicated that although students possessed basic knowledge of laboratory safety, they lacked adequate understanding of safety rules, symbols, and appropriate laboratory behavior, and many demonstrated low confidence in handling laboratory activities safely. The study implies that insufficient safety awareness among students may increase the likelihood of laboratory accidents, thereby justifying its consideration as a predictor of accident avoidance.

Similarly, Ezenwobodo (2024) investigated the implementation of safety practices in secondary school laboratories in Nigeria using a survey research design involving students and teachers. Data were collected using a structured Likert-scale questionnaire validated by experts. The findings revealed that although safety practices were implemented to a reasonable extent, there were inconsistencies in compliance and enforcement of safety rules, which could expose students to laboratory hazards. The study implies that the mere presence of safety practices is not sufficient; proper implementation and adherence are critical for ensuring accident prevention in laboratory settings.

In addition, Sumile and Malinao (2026) assessed the level of laboratory safety awareness among science education students using a quantitative descriptive survey design. Data were collected using a validated questionnaire, and the findings showed that students generally demonstrated a high level of safety awareness, although the level varied significantly based on experience and exposure. The study implies that safety awareness plays a crucial role in minimizing laboratory risks, but continuous reinforcement is necessary to sustain safe practices among students.

Collectively, these studies highlight the importance of laboratory facilities, safety practices, and safety awareness in enhancing effective teaching and learning

of physics. However, most of the reviewed studies focused on laboratory equipment, types of accidents, or safety awareness independently, with limited attention given to the combined influence of personal protective equipment and safety awareness on accident avoidance. This gap underscores the need for the present study.

Purpose of the study

The purpose of this study is to determine the influence of laboratory safety practices on accident avoidance among secondary school physics students in Calabar Municipality. Specifically, the study seeks to:

i. Investigate the influence of the use of personal protective equipment on accident avoidance in physics laboratories among secondary school students in Calabar Municipality.

ii. Investigate the influence of safety awareness on accident avoidance in physics laboratories among secondary school students in Calabar Municipality.

Research questions

i. Does the use of personal protective equipment influence accident avoidance in physics laboratories among secondary school students in Calabar Municipality?

ii. Does safety awareness influence accident avoidance in physics laboratories among secondary school students in Calabar Municipality?

Research hypotheses

i. The use of personal protective equipment does not significantly influence accident avoidance in physics laboratories among secondary school students in Calabar Municipality.

ii. Safety awareness does not significantly influence accident avoidance in physics laboratories among secondary school students in Calabar Municipality.

Methodology

A correlational survey research design was adopted for the study to generate data based on respondents' opinions using a questionnaire. The population of the study consisted of 2,623 Senior Secondary School Two (SS II) physics students in Calabar Municipality, Cross River State. A sample size of 347 physics students was selected using a simple random sampling technique. Calabar Municipality was chosen as the study area because reports from schools within the area indicate the occurrence of laboratory-related accidents and inconsistent adherence to safety practices during physics practical sessions. In addition, many secondary schools in the area face challenges such as inadequate safety equipment and limited emphasis on safety awareness, which may expose students to laboratory hazards. These conditions make the area suitable for investigating the influence of laboratory safety practices on accident avoidance among students. The sample size was determined using Taro Yemane's formula as shown below:

$n=N/1+N(e)^2$

Where:

n= Sample size

N = population size

1= constant

e = margin of error (0.05 at 95% confidence level)

Step-by-Step Calculation

Population size (N) = 692

Margin of error (e) = 0.05

Compute denominator:

$1 + N(e)^2 = 1 + 2623(0.05^2)$

$= 1 + 2623(0.0025)$

$= 1 + 6.5575$

$= 7.5575$

Divide N by denominator:

$n = 2623 / 7.5575$

$n = 347$

A structured 20-item questionnaire, titled Laboratory Safety Practices Questionnaire (LSPQ), was used to elicit information from the respondents. The questionnaire focused on two laboratory safety variables: personal protective equipment and safety awareness. It consisted of two clusters (A and B)

corresponding to the variables, and it adopted a four-point Likert scale of Strongly Agree (SA), Agree (A), Disagree (D), and Strongly Disagree (SD). The instrument was validated through face and content validation by experts in science education.

The reliability of the instrument was determined using Cronbach's alpha method, which yielded a reliability coefficient between 0.81- 0.88, indicating high internal consistency. The questionnaires were administered and collected, and the data obtained were analyzed using simple linear regression.

Results

Research question one

Does the use of personal protective equipment influence accident avoidance in physics laboratories among secondary school students in Calabar Municipality?

Hypothesis one

The use of personal protective equipment does not significantly influence accident avoidance in physics laboratories among secondary school students in Calabar Municipality.

Table 1: Regression of Accident Avoidance on Laboratory Safety Practices among Secondary School Physics Students in Calabar Municipality, Cross River State, Nigeria.

R		**R^2**	**Adjusted R^2**		**Std. Error**
.827		.684	.682		2.902
Source	Df	Sum of Squares	Mean Square	F	Sig.
Regression	1	4226.280	4226.280	628.320	.000
Residual	345	5541.468	16.062		
Total	346	9767.758			
Variable	Unstandardized B	Std. Error	Standardized Beta	T	Sig.
Constant	14.263	.826		17.27	.000
Personal Protective Equipment	1.003	.058	.827	25.07	.000

Model Summary (Research Question)

Interpretation

To answer Research Question One, the result in Table 1 shows that the coefficient of determination (R^2=0.684) indicates that personal protective equipment explains 68.4% of the variance in accident avoidance in physics laboratories among secondary school students in Calabar Municipality. This implies that the use of personal protective equipment has a strong influence on accident avoidance in physics laboratories.

The ANOVA results show that the model is statistically significant ($F(1,345)=628.320$, $p<0.05$), indicating that PPE is a significant predictor of accident avoidance. The regression coefficient for PPE ($B = 1.003$, $p < 0.05$) indicates a positive and significant relationship between PPE and accident avoidance. This implies that a unit increase in PPE use leads to a corresponding increase in accident avoidance. The regression equation is expressed as: Accident Avoidance = 1.003(PPE) + 14.263. Since the p-value is less than 0.05, the null hypothesis is rejected. Therefore, the use of personal protective equipment significantly influences accident avoidance in physics laboratories among secondary school students in Calabar Municipality.

Research question two

Does safety awareness influence the avoidance of accidents in the physics laboratory among secondary school students in Calabar Municipality?

Hypothesis two

Safety awareness does not significantly influence accident avoidance in physics laboratories among secondary school students in Calabar Municipality.

Table 2: Simple Linear Regression Analysis of Safety Awareness and Accident Avoidance

R		**R^2**	**Adjusted R^2**		**Std. Error**
.782		.612	.611		2.764
Source	Df	Sum of Squares	Mean Square	F	Sig.
Regression	1	4083.324	4083.324	526.412	.000
Residual	345	5988.821	17.36		
Total	346	10072.145			
Variable	Unstandardized B	Std. Error	Standardized Beta	T	Sig.
Constant	13.554	.902		15.03	.000
Safety Awareness	.866	.070	.782	12.78	.000

Interpretation

To answer Research Question Two, the result in Table 2 shows that the coefficient of determination (R^2=0.612) indicates that safety awareness explains 61.2% of the variance in accident avoidance in physics laboratories among secondary school students in Calabar Municipality. This implies that safety awareness has a strong influence on accident avoidance in physics laboratories.

The ANOVA results show that the model is statistically significant ($F(1,345)=526.412, p<0.05$), indicating that safety awareness is a significant predictor of accident avoidance. The regression coefficient for safety awareness ($B=0.866, p<0.05$) shows a positive and significant relationship between safety awareness and accident avoidance. This implies that an increase in safety awareness leads to an increase in accident avoidance among students. The regression equation is expressed as:

Accident Avoidance = 0.866(Safety Awareness) + 13.554. Since the p-value is less than 0.05, the null hypothesis is rejected. Therefore, safety awareness significantly influences accident avoidance in physics laboratories among secondary school students in Calabar Municipality.

Discussion of Findings

The major finding of this study shows that personal protective equipment (PPE) and safety awareness jointly play significant roles in promoting accident avoidance in physics laboratories among secondary school students in Calabar Municipality. This

indicates that laboratory safety is not determined by a single factor but by a combination of protective resources and students' safety knowledge and behavior. One key finding is that the use of personal protective equipment enhances students' ability to avoid laboratory accidents. This suggests that when students consistently use safety goggles, gloves, laboratory coats, and other protective tools, their exposure to physical, chemical, and electrical hazards is significantly reduced. This finding is consistent with Bello (2012), who emphasized that effective utilization of laboratory equipment contributes not only to improved learning outcomes but also to safer laboratory environments. Although Bello focused broadly on equipment utilization, the implication of safe handling aligns with the present finding that protective materials are essential in minimizing risks during practical work.

Similarly, Anaekwe and Nweke (2021) reported that most laboratory accidents such as cuts, burns, and electric shocks arise from improper handling of apparatus and poor safety compliance. This supports the present finding that PPE serves as a preventive mechanism against avoidable laboratory injuries. The implication is that even when laboratory equipment is available, students remain vulnerable unless appropriate protective measures are actively used. Ezenwobodo (2024) further reinforces this view by noting that inconsistent compliance with safety rules exposes students to avoidable hazards, suggesting that the effectiveness of PPE depends largely on strict adherence to its use during laboratory activities.

Another major finding is that safety awareness significantly contributes to accident avoidance in physics laboratories. This implies that students who understand laboratory rules, hazard symbols, and safe operational procedures are more likely to behave cautiously during experiments. This finding is supported by Ponferrada et al. (2017), who found that students with positive safety awareness demonstrated better perception and application of safety measures in reducing laboratory risks. This suggests that awareness influences behavior, which in turn reduces accidents.

Caymaz (2021) further observed that although students may possess basic knowledge of laboratory safety, gaps in understanding safety symbols and procedures limit their ability to apply safety principles effectively. This aligns with the present finding by showing that incomplete safety awareness can still expose students to laboratory hazards. In addition, Sumile and Malinao (2026) reported that safety awareness improves with exposure and experience, indicating that continuous reinforcement is necessary for sustained safe behavior. This reinforces the idea that safety awareness is not static but develops through consistent instruction and practice.

Overall, the findings of this study demonstrate that laboratory accident avoidance is strongly influenced by both physical safety provisions (PPE) and behavioral-cognitive factors (safety awareness). While PPE provides immediate physical protection, safety awareness ensures correct behavior and decision-making in laboratory environments. The interaction of these two factors explains the reduction in laboratory accidents among students and highlights the need for a combined approach to laboratory safety management.

Conclusion

Based on the results and findings of the study, it was concluded that personal protective equipment (PPE) and safety awareness significantly influence accident avoidance in physics laboratories among senior secondary school students in Calabar Municipality. The study established that the consistent use of PPE, together with adequate safety awareness, plays a critical role in reducing laboratory-related accidents and ensuring safe handling of apparatus during practical activities. Therefore, accident prevention in the physics laboratory is largely dependent on both the availability of safety equipment and the extent to which students understand and adhere to laboratory safety procedures.

In terms of implication for laboratory safety policy, the findings suggest that school authorities and education policymakers should strengthen and enforce comprehensive laboratory safety policies that mandate the provision and compulsory use of PPE in all science practical sessions. Safety regulations should not only exist in policy documents but must be actively implemented and monitored to ensure compliance in all secondary schools.

For science teachers, the findings imply that greater emphasis should be placed on safety education during laboratory instruction. Teachers are expected to integrate safety awareness into practical lessons by consistently demonstrating correct laboratory procedures, explaining potential hazards, and ensuring that students strictly observe safety rules before, during, and after experiments. This will help cultivate a culture of safety consciousness among learners.

For school administrators, the study implies the need to prioritize the provision of adequate laboratory facilities, including essential PPE and safety equipment. Administrators should also organize regular safety training and monitoring systems to ensure that both teachers and students comply with established laboratory safety standards. By doing so, schools can create a safer learning environment that minimizes risks and enhances effective science teaching and learning.

Overall, the study emphasizes that effective accident prevention in physics laboratories requires a coordinated effort among policymakers, teachers, and school administrators to ensure both safety awareness and the provision of protective resources.

Recommendations

The following recommendations were made based on the findings of the study:

i. Government and educational authorities should ensure that secondary school physics laboratories are adequately equipped with essential safety apparatus, particularly personal protective equipment (PPE) such as safety goggles, laboratory coats, gloves, and first aid materials. These safety resources should be made compulsory and consistently available in all science laboratories to reduce the risk of accidents during practical activities.

ii. Physics teachers should incorporate structured laboratory safety training into regular instructional practices. This should include explicit demonstrations on the correct use of laboratory equipment and PPE before students engage in practical work. Teachers should also consistently reinforce safety rules and clearly explain the consequences of non-compliance in order to develop strong safety consciousness among students. School administrators should establish strict monitoring systems to ensure compliance with laboratory safety rules by both teachers and students. Regular supervision of laboratory activities should be carried out to ensure that safety procedures are properly followed and that PPE is used appropriately during all practical sessions.

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