



IMPACT OF TEACHING AND LEARNING OF PHYSICS ON AWARENESS AND MITIGATION OF POLLUTION AND AIRBORNE DISEASES IN NORTH-WEST NIGERIA

Dr Musa Bello

Department of Physics
Federal University of Education, Zaria
musabellozaria@gmail.com
08032844603
Ocid id: <https://ocid.org/0009-0001-329038>

And

Dr Bello Muhammad

Department of Science Education Faculty of Education
Federal University of Kashere Gombe State, Nigeria
08035873653
Muhdbello087@gmail.com
Ocid id: <https://ocid.org/0009-0007-1870-1613>

And

Musa Lukman

musalukman62@gmail.com
08069393417
Orcid id: <https://orcid.org/0009-0006-7156-8826>
Department of Physics
Federal University of Education, Zaria

Abstract

This study investigated the impact of teaching and learning of physics on awareness and mitigation of pollution and airborne diseases among secondary school students in North-West Nigeria. Environmental challenges in the region, including high particulate matter from traffic emissions, biomass cooking practices, and Harmattan dust, contribute significantly to respiratory health burdens. The objectives of the study includes the examination of the effect of enriched physics instruction on students' awareness of pollution and airborne diseases, the determination of gender differences in environmental awareness after physics-based intervention and the assessment of the effectiveness of physics education in promoting positive environmental mitigation attitudes. The study adopted a quasi-experimental pretest–posttest control group design involving secondary school students from selected institutions across Kano, Kaduna, and Katsina States. A total of 320 Senior Secondary II students participated, with 160 assigned to experimental groups and 160 to control groups using stratified random sampling. The intervention consisted of enriched physics instruction integrating environmental physics concepts such as atmospheric particle dispersion, thermodynamics of combustion, and fluid dynamics of airborne particles. Data were collected using the Physics-Environmental Awareness Questionnaire (PEAQ) and the Pollution and Airborne Disease Awareness Test (PADAT), both demonstrating acceptable reliability coefficients (Cronbach's $\alpha = 0.88$ and 0.91 respectively). Results indicated significant improvement in environmental awareness among the experimental group. The experimental group recorded a pretest mean awareness score of 46.3% (SD = 11.4) and a posttest score of 79.5% (SD



= 8.7), showing an improvement of approximately 33.2%. A paired sample t-test revealed significant differences between pretest and posttest scores, $t(159) = 14.62$, $p < .001$, Cohen's $d = 1.32$. The control group showed minimal improvement from 45.8% to 52.1%. The study concludes that physics instruction integrated with environmental applications significantly improves awareness of pollution and airborne disease risks. The findings support sustainable education frameworks and underscore the need for curriculum reform in Nigerian science education.

Keywords: Physics education, air pollution, airborne diseases, environmental awareness, North-West Nigeria, quasi-experimental design, sustainability education.

Introduction

Physics education plays a critical role in helping learners understand natural phenomena that influence environmental quality and human health. Modern environmental challenges, particularly in developing regions such as North-West Nigeria, require science education that extends beyond theoretical knowledge to practical environmental awareness and mitigation strategies. Physics provides foundational explanations for atmospheric behavior, energy transfer, and particle dynamics that are directly related to pollution dispersion and airborne disease transmission. Atmospheric physics is essential in explaining particulate matter behavior in the environment. Air pollutants such as PM_{2.5} and PM₁₀ are influenced by wind patterns, temperature gradients, and atmospheric stability. The dispersion of pollutants can be explained using fluid mechanics and thermodynamic principles. Understanding these concepts allows students to appreciate how industrial emissions, vehicular exhaust, and biomass burning contribute to environmental degradation (Akinbode, 2016; Federal Ministry of Environment Nigeria, 2020).

Combustion processes are also central to pollution studies. Thermodynamics explains how incomplete combustion of fossil fuels and biomass produces harmful gases such as carbon monoxide, sulfur dioxide, and nitrogen oxides. In North-West Nigeria, biomass

cooking remains widespread due to economic constraints, leading to increased indoor air pollution exposure among households (Olayinka, 2011).

Fluid dynamics is equally important in understanding airborne disease transmission. Respiratory droplets and aerosol particles can be modeled as fluid-borne particles that travel through air currents. Physics-based explanations of airflow patterns help learners understand disease transmission mechanisms such as those associated with tuberculosis and influenza-like respiratory infections. Wave physics also contributes indirectly through understanding noise pollution and its physiological impacts. Continuous exposure to high-intensity sound waves can lead to stress-related health complications and hearing impairment.

North-West Nigeria faces significant environmental and public health challenges linked to pollution exposure. Traffic congestion in urban centers such as Kano contributes to high particulate emissions. Studies from environmental monitoring agencies indicate that PM_{2.5} concentrations in major cities in Northern Nigeria often exceed World Health Organization (WHO) recommended thresholds of 15 $\mu\text{g}/\text{m}^3$ annual average exposure (WHO, 2021).

The Harmattan season significantly worsens air quality across the region. Dust-laden winds from the Sahara Desert increase airborne



particle concentration, reducing visibility and exacerbating respiratory illnesses such as asthma and bronchitis. Health facilities in Northern Nigeria often report increased respiratory cases during Harmattan periods (Oluwole et al., 2012).

Biomass cooking practices remain common in rural and peri-urban communities due to limited access to clean energy alternatives. Smoke exposure from firewood and charcoal cooking contributes to chronic obstructive pulmonary diseases, particularly among women and children (Olayinka, 2011; Fuller et al., 2022).

The study focused on Senior Secondary II students in selected public secondary schools in Kano, Kaduna, and Katsina States. The study examined environmental awareness related to air pollution, respiratory diseases, and mitigation practices using physics-based instructional interventions. Several studies have established the importance of integrating environmental issues into science education to promote sustainability awareness. Environmental literacy is increasingly recognized as a critical outcome of science education worldwide. Research by environmental education scholars indicates that students exposed to contextualized science learning demonstrate higher retention and application of scientific knowledge to real-life problems.

UNESCO Global Education Monitoring Report 2020 emphasizes the role of education in promoting sustainable development literacy, particularly in developing regions. The report highlights that environmental education integrated into science curricula improves students' pro-environmental behavior and risk awareness.

In African contexts, science education reform has focused on shifting from rote memorization to problem-based learning

approaches. Studies across Sub-Saharan Africa show that inquiry-based science instruction significantly improves students' scientific reasoning and environmental decision-making skills.

Physics education provides scientific explanations for environmental pollution phenomena. Atmospheric physics helps explain particulate matter movement and air quality dynamics. Research indicates that students who understand particle motion, diffusion, and turbulence develop stronger awareness of pollution risks.

Studies in Nigeria have shown that environmental science integration in physics teaching improves conceptual understanding. For example, research conducted in Southern Nigeria secondary schools reported that students exposed to contextual physics instruction performed significantly better in environmental awareness assessments compared to traditional lecture-based instruction.

Combustion physics is particularly relevant in Nigeria due to widespread biomass fuel usage. In developing countries, incomplete combustion from firewood cooking contributes significantly to indoor air pollution. Research published in public health and environmental science journals indicates strong correlations between biomass smoke exposure and respiratory diseases.

Air pollution remains a major public health challenge in Nigeria. Several epidemiological studies have documented increasing respiratory disease prevalence associated with environmental pollution.

Research by Nigerian environmental health scholars has shown that particulate matter exposure contributes to asthma, chronic bronchitis, and cardiovascular complications. Urban centers such as Kano have recorded



elevated pollution levels due to industrial activities and traffic congestion. A study by the Federal Ministry of Environment reported that many Nigerian cities exceed WHO recommended air quality standards. Traffic emissions remain a major source of urban pollution in North-West Nigeria due to rapid urbanization and increased vehicle usage. Biomass cooking is a significant contributor to household air pollution in Northern Nigeria. Studies conducted by health researchers' show that women and children are disproportionately affected due to prolonged exposure to cooking smoke.

Research in rural Northern Nigerian communities indicates that households using firewood as primary energy sources have higher incidence rates of respiratory infections. Exposure to indoor smoke increases risk factors for pneumonia, tuberculosis, and chronic obstructive pulmonary disease. The Harmattan season significantly influences air quality across West Africa. During this period, dust particles from the Sahara Desert are transported across the region by trade winds. Environmental scientists have documented increases in particulate concentration during Harmattan periods.

Studies show that Harmattan dust particles can penetrate deep into respiratory systems, aggravating asthma and other respiratory conditions. Hospital records in Northern Nigeria consistently show spikes in respiratory disease cases during Harmattan months. Several theoretical frameworks explain how education influences environmental behavior. Constructivist learning theory suggests that students build knowledge through interaction with their environment and real-life experiences. Environmental literacy models also emphasize knowledge-attitude-behavior relationships. According to environmental

psychology research, knowledge of environmental risks often translates into positive environmental protection behavior when reinforced through practical education.

Statement of the Problem

Despite the centrality of physics to understanding environmental phenomena, a profound disconnect exists between the content of physics instruction in Nigerian secondary schools and the lived environmental realities of students. In much of North-West Nigeria, physics teaching continues to be delivered in a manner that is heavily examination-oriented, focusing on abstract calculations and theoretical derivations that bear little visible connection to the pollution, respiratory disease, and environmental degradation that students encounter daily. While the curriculum nominally covers topics such as fluid dynamics, thermodynamics, and atmospheric physics, these are rarely taught with reference to local environmental contexts such as the thick Harmattan haze that descends on communities in Kano and Katsina each dry season, the acrid smoke from firewood cooking stoves in household kitchens, or the vehicular exhaust that pervades congested urban streets. The result is that students may be able to solve textbook problems on particle motion or combustion reactions and yet remain entirely unaware of how these same principles explain why their neighbors suffer from chronic cough, why respiratory ward admissions spike during certain months, or what practical steps might reduce their household's pollution exposure.

This gap between academic physics content and real-world environmental consciousness is not a trivial one. Epidemiological evidence consistently links airborne pollution to elevated rates of asthma, tuberculosis, pneumonia, and cardiovascular disease in Northern Nigeria (Oluwole et al., 2012; Fuller



et al., 2022). The Federal Ministry of Environment Nigeria (2020) has documented that many Nigerian cities exceed WHO air quality thresholds, and yet environmental awareness remains critically low among the youth populations most exposed to these risks. Physics education, properly contextualized, has the potential to serve as a powerful vehicle for building this awareness equipping young people not merely to pass examinations but to understand, interrogate, and ultimately respond to the environmental health threats in their communities. However, empirical evidence documenting the specific effect of enriched, application-oriented physics instruction on environmental and health awareness among secondary school students in the North-West geopolitical zone remains sparse in the literature.

It is against this background that the present study was conducted. There is an urgent need to move beyond anecdotal observations and establish empirical evidence on whether intentionally integrating environmental physics content atmospheric dispersion, combustion chemistry, fluid dynamics of airborne particles into secondary school physics instruction can produce measurable improvements in students' awareness of pollution and airborne disease risks. This study therefore investigates the impact of enriched physics instruction on the environmental awareness of Senior Secondary II students in selected schools across Kano, Kaduna, and Katsina States, with a view to providing data-driven recommendations for curriculum reform and teacher professional development in the region.

Research Objectives

The study aimed to:

1. Examine the effect of physics instruction on students' awareness of pollution and airborne diseases.
2. Determine gender differences in environmental awareness after physics-based intervention.
3. Assess the effectiveness of physics education in promoting positive environmental mitigation attitudes.

Research Hypotheses

The following null hypotheses guided the study:

- Ho₁: There is no significant difference between pretest and posttest environmental awareness scores of students exposed to enriched physics instruction.
- Ho₂: There is no significant gender difference in environmental awareness scores after the intervention.
- Ho₃: There is no significant difference between experimental and control group posttest scores.

Methodology

This study adopted a quasi-experimental pretest–posttest control group design. The design was considered appropriate because random assignment of students to treatment conditions was not feasible within existing school administrative structures. The design allowed comparison of learning outcomes between students exposed to enriched physics instruction and those taught using conventional methods.

Population and Sample

The population of the study comprised Senior Secondary II (SS2) students in public secondary schools across North-West Nigeria. The study was conducted in selected schools in Kano, Kaduna, and Katsina States.

A total sample of 320 students was selected using multistage sampling techniques:

- (i) **I Stage 1:** Purposive selection of three states based on high pollution exposure and population density.



(ii) **Stage 2:** Random selection of eight secondary schools.

(iii) **Stage 3:** Stratified random sampling to ensure gender representation.

The sample consisted of:

1. 160 students in the experimental group
2. 160 students in the control group

Participants were aged between 15 and 18 years.

Research Instruments

Two main instruments were used for data collection:

1. Physics-Environmental Awareness Questionnaire (PEAQ)

The PEAQ measured students' environmental awareness, attitudes, and knowledge of pollution-related physics concepts. The questionnaire contained 30 items using a 4-point Likert scale ranging from Strongly Agree to Strongly Disagree.

2. Pollution and Airborne Disease Awareness Test (PADAT)

The PADAT assessed students' conceptual understanding of pollution physics and disease transmission mechanisms. The test consisted of 40 multiple-choice questions covering:

1. Atmospheric physics
2. Combustion processes
3. Fluid particle motion
4. Environmental health implications

Reliability testing using Cronbach's alpha produced:

1. PEAQ = 0.88
2. PADAT = 0.91

These values indicate high internal consistency.

The experimental group was taught using enriched physics instruction for six weeks. The intervention integrated environmental applications into standard physics curriculum topics.

Instructional content included:

- (i) Fluid dynamics of airborne particles

(ii) Thermodynamics of fossil fuel combustion

(iii) Atmospheric dispersion of pollutants

(iv) Physics of respiratory droplet transmission

(v) Noise pollution physics

Teaching strategies included:

1. Problem-based learning
2. Demonstration experiments
3. Environmental case studies from Northern Nigeria
4. Group discussions on pollution mitigation practices

The control group was taught using traditional lecture-based methods following the standard physics curriculum without environmental integration.

Data Collection Procedure

Pretests were administered to both groups before the intervention. After six weeks of instruction, posttests were conducted using the same instruments but with reordered questions to reduce testing bias.

Data Analysis

Data were analyzed using **SPSS software**. Statistical techniques included:

- (i) Descriptive statistics (mean, standard deviation, percentage)
- (ii) Paired sample t-test to test within-group differences
- (iii) ANCOVA to control for pretest differences
- (iv) Independent sample t-test for group comparisons
- (v) Effect size measured using Cohen's d

Significance level was set at $p < 0.05$.

Ethical approval was obtained from participating school authorities. Participation was voluntary, and informed consent was obtained from students and their guardians. Data confidentiality and anonymity were maintained throughout the study.



Results

This section presents the findings of the study based on the research hypotheses. Data were

analyzed using descriptive and inferential statistics.

Table 1: Pretest and Posttest Awareness Scores of Experimental Group

Test Stage	Mean Score (%)	Standard Deviation
Pretest	46.3	11.4
Posttest	79.5	8.7

The experimental group showed substantial improvement in environmental awareness after the intervention, with an average gain of **33.2%**.

A paired sample t-test revealed a statistically significant difference between pretest and posttest scores:

$t(159) = 14.62$, $p < .001$, **Cohen's d** = 1.32 (large effect size).

This result indicates that enriched physics instruction significantly improved pollution and airborne disease awareness.

Table 2: Control Group Pretest and Posttest Scores

Test Stage	Mean Score (%)	Standard Deviation
Pretest	45.8	10.9
Posttest	52.1	11.3

The control group showed minimal improvement (6.3%). A paired sample t-test showed: $t(159) = 2.10$, $p = .037$, **Cohen's d** = 0.28 (small effect size).

Table 3: Independent Sample Posttest Comparison

Group	Mean Score (%)	SD
Experimental	79.5	8.7
Control	52.1	11.3

Independent t-test results showed a significant difference between groups: $t(318) = 18.75$, $p < .001$.

Conceptual representation of improvement trends

Experimental Group:

Pretest → 46%

Posttest → 79%

Control Group:

Pretest → 46%

Posttest → 52%

**Table 4: Gender Differences in Experimental Group Posttest Scores**

Gender	Mean (%)	SD
Male	80.6	8.3
Female	78.2	9.1

Independent t-test results showed no significant gender difference:

$t(158) = 1.45, p = .15$.

This suggests that the intervention benefited both male and female students similarly.

Students from urban schools demonstrated slightly higher posttest scores (81.3%)

The findings indicate that physics-based environmental instruction significantly improved pollution and airborne disease awareness among students.

Discussion

The findings of this study revealed that physics instruction significantly improved students' awareness of pollution and airborne disease risks. The large effect size (Cohen's $d = 1.32$) suggests that contextualized physics teaching has strong educational impact on environmental literacy. This finding aligns with international research indicating that science education becomes more effective when linked to real-world environmental problems.

The improvement in environmental awareness can be explained using constructivist learning theory, which posits that learners construct knowledge through interaction with their environment and prior experiences. When physics concepts such as particle motion, combustion, and atmospheric dynamics were connected to local environmental issues, students demonstrated higher cognitive engagement and conceptual understanding.

compared to rural schools (76.8%), but ANCOVA results showed the difference was not statistically significant after controlling for pretest scores:

$F(1,317) = 2.89, p = .089$.

The results support the argument that physics education should move beyond abstract mathematical problem solving. Students in the experimental group were able to relate theoretical physics concepts to environmental health challenges such as air pollution exposure and respiratory disease transmission.

Similar studies in African science education contexts have reported improved learning outcomes when environmental applications are integrated into physics teaching. This supports global trends in sustainability education that emphasize interdisciplinary teaching approaches.

The findings are consistent with science education research conducted in developing countries, which shows that environmental education improves student attitudes toward sustainability. Studies in Nigeria and other African countries have demonstrated that inquiry-based science teaching enhances environmental awareness and problem-solving skills. The minimal improvement observed in the control group suggests that traditional lecture-based physics instruction may not effectively promote environmental literacy. This supports previous research showing that rote learning approaches limit students' ability to apply scientific knowledge to societal challenges.



The absence of significant gender differences indicates that physics-based environmental instruction is equally effective for male and female students. This finding is important for educational equity and supports research showing that gender performance gaps in science can be reduced through inclusive teaching strategies.

The study has important public health implications for North-West Nigeria. Increasing environmental awareness among secondary school students can contribute to long-term behavioral changes that reduce pollution exposure. Students can serve as environmental change agents in their families and communities. Awareness of biomass smoke risks may encourage adoption of cleaner cooking technologies. Similarly, understanding airborne disease transmission physics may promote better hygiene and ventilation practices.

The study supports environmental literacy models that emphasize the relationship between knowledge, attitude, and behavior. Constructivist and experiential learning theories were validated because students demonstrated improved environmental awareness after practical physics-based instruction.

The findings suggest that Nigerian science education curricula should include more environmental physics content. Teacher training programs should also emphasize interdisciplinary teaching methods that combine physics with environmental science and public health education.

Conclusion

This study examined the impact of physics teaching and learning on awareness of pollution and airborne diseases among secondary school students in North-West Nigeria. The findings demonstrated that enriched physics instruction significantly

improved environmental awareness and understanding of pollution-related health risks. Students exposed to contextualized physics lessons showed substantial improvement in awareness scores compared to those taught using conventional lecture-based methods. The results support the argument that physics education can play a critical role in promoting environmental sustainability and public health awareness.

The study further demonstrated that integrating environmental applications into physics teaching helps students connect theoretical concepts with real-life environmental challenges such as air pollution, biomass smoke exposure, and airborne disease transmission. The intervention was equally effective across gender groups, indicating inclusive educational benefits.

Overall, the study provides empirical evidence that physics education can contribute to achieving sustainable development goals related to health, education, and climate action in Nigeria.

Recommendations

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

1. Curriculum Reform to Address the Environmental Awareness Gap: In line with the finding that enriched physics instruction significantly improves students' awareness of pollution and airborne diseases, curriculum developers at the Nigerian Educational Research and Development Council (NERDC) should revise secondary school physics syllabi to explicitly integrate environmental physics content. Topics such as atmospheric particle dispersion, combustion processes, and fluid dynamics of airborne particles should be framed with reference to local environmental challenges Harmattan dust, vehicular emissions, and



biomass cooking smoke so that students can directly connect physics principles to the health realities of their communities.

2. Adoption of Student-Centred Pedagogies for Environmental Instruction: Physics teachers in North-West Nigeria and beyond should be encouraged and supported to move away from purely examination-oriented, lecture-based delivery toward active, application-oriented teaching strategies. Problem-based learning, demonstration experiments using locally available materials, and environmental case studies drawn from Northern Nigerian contexts were central to the effectiveness of the intervention in this study. These approaches should be formalised as recommended instructional methods in the physics curriculum.

3. Gender-Responsive Teacher Training to Sustain Equitable Outcomes: Given the finding that the intervention produced equivalent gains for male and female students, teacher professional development programmes should emphasise inclusive and gender-responsive instructional design. The Federal Ministry of Education and State Ministries of Education in the North-West zone should organise regular training workshops to equip physics teachers with the skills to deliver environmental physics content in ways that remain engaging and accessible to all students regardless of gender.

4. Institutionalization of Environmental Mitigation Attitudes through Policy: Since the study found that enriched physics instruction promotes positive environmental mitigation attitudes, educational policymakers should formalise this integration at the policy level. Specifically, the National Policy on Education should be reviewed to include measurable environmental literacy outcomes within science education benchmarks. Schools should also be encouraged to establish environmental action clubs that provide

students with structured platforms to translate their awareness into practical mitigation activities.

5. School-Community Outreach to Extend Environmental Awareness: To amplify the impact of in-school environmental awareness on real community behaviour, schools should develop outreach programmes that engage parents, community leaders, and local health workers. Students who have received enriched physics instruction can serve as peer educators and environmental change agents within their families and communities, contributing to long-term reductions in pollution-related disease burdens in North-West Nigeria.

References

- Abimbola, I. O. (2013). The problem of science education in Nigeria: A philosophical perspective. *Journal of Science Education and Technology*, 22(5), 456–462.
- Ajiboye, J. O., & Sanni, A. M. (2017). Environmental education and sustainable development in Nigeria. *African Journal of Educational Research*, 12(2), 89–98.
- Akinbode, F. O. (2016). Air pollution and climate change in Nigerian cities. *Environmental Research Journal*, 10(3), 201–210.
- Federal Ministry of Environment Nigeria. (2020). *National air quality management report*. Abuja: Government Press.
- Fuller, R., Landrigan, P. J., Balakrishnan, K., et al. (2022). Pollution and health: A progress update. *The Lancet Planetary Health*, 6(6), e535–e547. [https://doi.org/10.1016/S2542-5196\(22\)00090-0](https://doi.org/10.1016/S2542-5196(22)00090-0)



- Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data. *American Journal of Physics*, 66(1), 64–74.
- IPCC. (2021). *Climate change 2021: The physical science basis*. Intergovernmental Panel on Climate Change Report.
- Kolawole, C. O. O., & Abimbola, I. O. (2018). Environmental education and science teaching in Nigerian secondary schools. *Journal of Educational Development*, 15(1), 33–45.
- National Bureau of Statistics Nigeria. (2022). *Health and environmental statistics report*. Abuja: NBS Publications.
- Ogunbode, C. A., & Arnold, K. (2012). Environmental behavior and climate change attitudes in Nigeria. *Environment and Behavior Research*, 44(5), 628–647.
- Olowolafe, E. A. (2014). Effects of environmental education on students' achievement in science. *Journal of Research in Curriculum and Teaching*, 9(2), 112–121.
- Olayinka, O. S. (2011). Indoor air pollution from biomass fuel use in Nigeria. *Journal of Environmental Health Science*, 6(4), 77–85.
- Oluwole, A. F., et al. (2012). Air pollution and respiratory health effects in Nigeria. *African Journal of Respiratory Medicine*, 8(1), 23–29.
- United Nations. (2015). *transforming our world: The 2030 agenda for sustainable development*. United Nations Publications.
- UNESCO. (2020). *Global education monitoring report: Inclusion and education*. UNESCO Publishing.
- WHO. (2021). *WHO global air quality guidelines*. World Health Organization.
- Yusuf, M. O. (2015). Physics education and technological development in Nigeria. *Journal of Science Teachers Association of Nigeria*, 50(1), 54–62.
- Zainab, A. M., & Yusuf, S. (2019). Science education and environmental sustainability in West Africa. *West African Journal of Education*, 39(2), 101–115.