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SPECIAL ISSUE: CELEBRATING 20 YEARS OF GEOGRAPHY IN KADUNA STATE UNIVERSITY - ADVANCES AND FRONTIERS IN GEOGRAPHY

Teachers' and Students' Perceptions of Artificial Intelligence-Based Approaches to Environmental Sanitation in Secondary Schools in the North Central Zone, Nigeria

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ABSTRACT

The study was motivated by ongoing sanitation challenges in schools and the growing potential of artificial intelligence (AI) technologies to improve hygiene and waste management. This study examined teachers' and students' perceptions of AI-based approaches to environmental sanitation in secondary schools in the North Central Zone of Nigeria. A descriptive survey research design was adopted. The population comprised secondary school teachers and students, from which a representative sample of 400 respondents (150 teachers and 250 students) was selected using stratified random sampling. Data were collected using a structured questionnaire and analyzed with mean scores, standard deviation, and t-test statistics to test the stated hypotheses. The findings revealed that 82% of teachers and 76% of students were aware of AI-based sanitation solutions, with teachers demonstrating slightly higher mean awareness scores (M = 3.42, SD = 0.48) than students (M = 3.28, SD = 0.52). Both groups exhibited positive attitudes toward AI integration, with mean attitude scores above the benchmark of 2.50. Major barriers identified included inadequate funding (reported by 78% of respondents), limited training opportunities (71%), unreliable electricity (69%), and weak administrative support (65%). The study concludes that while awareness and attitudes are favourable, infrastructural and institutional deficiencies constrain effective adoption. It is recommended that targeted training, workshops, and funding support be provided to strengthen the implementation of AI-based sanitation systems in schools.

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1 Introduction

Rapid urbanisation, population growth, and inadequate public services have made environmental sanitation a persistent challenge across many Nigerian communities, and schools are no exception. Poor waste handling, blocked drains, insufficient toilet and hygiene facilities in and around secondary schools create health risks for learners and staff, reduce school attendance, and undermine the broader goals of healthy learning environments (Bharadwaj & Srivastava, 2021). In parallel, Artificial Intelligence (AI) technologies, including computer vision for waste sorting, predictive analytics for collection routing, sensor-based monitoring of sanitation infrastructure, and chatbots for behavior-change communication, have matured sufficiently to offer practical tools for environmental sanitation and waste management interventions (Ofem, 2024). In Nigeria, university partnerships and pilot projects are already exploring AI-driven waste sorting and predictive waste management systems to improve collection efficiency and resource recovery (Ogunyemi et al., 2023).

Within education, the adoption of artificial intelligence (AI) has expanded rapidly in recent years, transforming teaching, learning, and administrative processes through adaptive learning platforms, intelligent tutoring systems, and data-driven decision-making (Luckin & Cukurova, 2021). Studies carried out by Sanusi (2025) across states in Nigeria show growing awareness among educators and students about AI's uses in instruction, but also highlight gaps in infrastructure, training, and contextualised policy guidance. Where AI has been applied to community or municipal sanitation, researchers report measurable gains (for example, improved routing, early detection of service failures, more effective public-engagement campaigns); yet these solutions often remain city-level or university-led pilots rather than school-embedded programmes (Igbokwe, 2024). This leaves a research and practice gap about how AI can be tailored to school settings and how the key actors in the school ecosystem (teachers and students) perceive such technologies when used specifically for environmental sanitation.

Perceptions matter; teacher and student attitudes shape the adoption, day-to-day use, and sustainability of any innovation introduced into schools. According to Adewumi and Olatunji (2022), AI in Nigerian educational contexts points to several recurring enablers and barriers: perceived usefulness, ease of use, access to devices and reliable connectivity, teacher confidence (self-efficacy), with technology, ethical concerns (data privacy, misuse), and the presence of targeted professional development.

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These factors influence not only whether AI tools are tried, but also whether they are integrated into routine school practices such as routine sanitation inspection, waste-reduction campaigns, and behaviour-change education.

Consequently, understanding teachers' and students' perceptions is a necessary precursor to designing AI interventions that are culturally appropriate, technically feasible, and pedagogically aligned to school routines. In North-Central Zone of Nigeria, teachers' and students' perceptions of artificial intelligence (AI)-based approaches to environmental sanitation varies due to schools varying levels of infrastructural readiness and institutional capacity, including challenges such as irregular electricity supply, weak waste-collection systems and limited ICT competence among teachers, alongside opportunities such as active student clubs, community partnerships and collaborations with local universities (Sanusi, 2025). This study was prompted by the uneven state of sanitation practices across schools within the study area. The study investigated teachers' and students' perceptions of Artificial Intelligence-based approaches to environmental sanitation in secondary schools in the North Central Zone, Nigeria.

Regardless of the growing interest in technological solutions, environmental sanitation in many secondary schools in the North-Central Zone remains poor, contributing to illnesses, absenteeism, and degraded learning environments. While Artificial Intelligence (AI) offers tools that could improve waste management, monitor sanitation infrastructure, and support hygiene education, the successful introduction of AI into schools depends heavily on how teachers and students perceive these technologies. Currently, there is limited empirical evidence about teachers' and students' awareness, attitudes, perceived usefulness, perceived barriers (infrastructure, training, cost, privacy), and behavioural intentions regarding AI-based sanitation approaches in this region. Without clear data on these perceptual and contextual variables, AI initiatives risk low uptake, misuse, or unsustained implementation. Therefore, it is necessary to investigate the perceptions, capacity gaps, and contextual constraints that influence teachers' and students' perceptions of Artificial Intelligence-based approaches to environmental sanitation in secondary schools in the North Central Zone, Nigeria, and whether AI-based sanitation innovations can be effectively adopted and maintained in North-Central Nigerian secondary schools.

Research Hypotheses

$H0_1$: There is no significant difference between teachers' and students' levels of awareness regarding artificial intelligence-based approaches to environmental sanitation in secondary schools.

$H0_2$: There is no significant relationship between teachers' and students' attitudes and the utilization of artificial intelligence-based approaches to environmental sanitation in secondary schools.

$H0_3$: There is no significant influence of perceived barriers on the adoption of artificial intelligence-based approaches to environmental sanitation in secondary schools.

2 LITERATURE REVIEW

Concept of Environmental Sanitation

Environmental sanitation in the school context refers to the set of facilities, services, and behaviours that keep the school environment safe, hygienic, and conducive to learning, including safe water supply, functional toilets, waste collection and disposal, drainage, and hygiene promotion. Lack of basic WASH (water, sanitation, hygiene) services in Nigerian schools is well documented and linked to greater disease risk, reduced attendance, and compromised learning (WHO & UNICEF, 2020; Balogun-Adeleye et al., 2021). In many Nigerian institutions, sanitation practices are often hindered by inadequate personnel, lack of funding, and poor maintenance culture (Adejumo & Olayinka, 2022). The need for more efficient and sustainable approaches to environmental cleanliness has led to the exploration of innovative technological solutions.

Artificial Intelligence (AI) and Its Educational Applications

AI is increasingly discussed in education for two related reasons: (a) as a subject to be taught (building future skills) and (b) as a set of tools that can augment instruction, assessment, and school administration. In Nigeria, national AI strategy initiatives and programmes (e.g., centres and AI academies) are emerging, but classroom-level implementation is still uneven due to infrastructure and teacher-capability gaps (Sanusi, 2025). Studies conducted by Sunday et al. (2025) show that teachers and schools in Nigeria recognised AI's potential for personalised learning, automated feedback, and administrative efficiency, yet concerns about training, equity, and policy translation remain salient.

AI-Based Approaches to Environmental Sanitation

Across the globe, AI applications for sanitation and waste management include computer-vision for automated waste sorting, machine-learning for predicting waste generation and optimizing collection routes, IoT sensors for fill-level and infrastructure monitoring and chatbots/mobile apps for citizen reporting and behaviour change. Comparative reviews emphasise meaningful gains (routing efficiency, reduced contamination, early

fault detection), but they also highlight transferability issues: data availability, cost, scalability, and community engagement particularly constrain uptake in African contexts (Nwokediegwu et al., 2024). In Nigeria, some pilot projects and municipal trials illustrate potential, but school-embedded AI sanitation interventions remain rare and under-evaluated.

Teachers' Role in AI-Integrated Environmental Education

Teachers are gatekeepers for technological innovation in schools: they shape adoption decisions, mediate student interactions with tools, and integrate new practices into curricula and routines. Nigerian research shows that teacher readiness on technical knowledge (TPACK), attitudes toward technology, and access to professional development strongly influence whether AI tools are adopted and sustained (Sunday et al., 2025). For sanitation specifically, teachers' willingness to use AI for monitoring (e.g., sensor dashboards), to lead student sanitation clubs supported by AI tools, or to use data from AI systems to target interventions will determine practical outcomes. Capacity gaps (training, time, institutional incentives) are recurrent barriers to teacher-led AI adoption.

Students' Role in AI-Based Environmental Practices

Students are both beneficiaries and active participants in school sanitation. In AI-enabled models, students can operate mobile reporting apps, participate in sensor-based monitoring teams, and respond to AI-driven behaviour-change nudges. Evidence from technology interventions suggests that student motivation, digital literacy, and opportunities for engagement (e.g., clubs, project work) influence the success of AI-based sanitation initiatives. Engaging students as co-designers or citizen reporters can strengthen local ownership and improve data quality, but this requires supportive supervision and appropriate safeguards (Nwokediegwu et al., 2024).

Perceptions and Attitudes toward AI in School Contexts

Perceptions, encompassing awareness, perceived usefulness, perceived ease of use, trust, and privacy concerns, are critical predictors of the intention to adopt AI tools. Recent studies in Nigeria and other developing contexts reveal mixed perceptions: while many teachers recognize AI's potential to enhance instruction, assessment, and administrative efficiency, adoption remains constrained by inadequate infrastructure, insufficient training, ethical concerns, and contextual limitations (Adeleke & Olatunji, 2023). Students' attitudes often reflect their teachers' dispositions and the overall school climate. Positive demonstrations, interactive exposure, and transparent communication about AI's purpose tend to strengthen trust and acceptance, whereas opaque systems or fears related to data misuse diminish confidence (Okafor et al., 2024). Therefore, examining both teachers' and students' perceptions specifically regarding AI applications in environmental sanitation rather than general educational AI use is essential to design contextually appropriate and sustainable solutions (Eze & Yusuf, 2024).

2.1 Theoretical Framework

Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM) developed by Davis (1989) posits that an individual's behavioral intention to use a technology is primarily determined by two key beliefs: perceived usefulness and perceived ease of use. In educational contexts, this model explains why teachers and students accept or resist emerging technologies such as Artificial Intelligence (AI). According to Sanusi (2025), these constructs are crucial in Nigeria, where limited exposure and infrastructural constraints often shape users' willingness to employ AI tools for educational or administrative purposes. Similarly, Sunday et al. (2025) found that perceived usefulness and institutional support significantly influenced secondary school teachers' acceptance of AI in instruction. Thus, TAM provides a framework for understanding how teachers and students perceive AI-based environmental sanitation solutions in schools, as these perceptions affect their adoption, usage behaviour, and sustainability. Importantly, TAM focuses on the individual decision-making process, explaining *why* users accept or reject AI tools based on personal beliefs and expected benefits.

Diffusion of Innovation (DoI) Theory

Rogers' (2003) Diffusion of Innovation Theory explains how new ideas, practices, and technologies spread through a social system over time. The theory identifies five attributes that influence adoption: relative advantage, compatibility, complexity, trialability, and observability. In relation to AI-based environmental sanitation, the DoI theory helps in understanding how teachers and students adopt such innovations based on perceived benefits, compatibility with existing school routines, and visibility of successful outcomes. Igbokwe (2024) emphasizes that where technological innovations are perceived to be complex or inconsistent with cultural and institutional norms, adoption rates tend to be low. This theoretical lens is therefore relevant for assessing how AI sanitation systems, such as smart bins, waste-monitoring sensors, or AI-driven sanitation campaigns, diffuse among teachers and students in Nigerian secondary schools. Unlike TAM, which focuses on individual attitudes, DoI explains the *process* through which AI innovations spread across the school community and gain collective acceptance over

time.

How the Theories Complement Each Other in this Study

The two theories, TAM and DoI, jointly provide a strong theoretical foundation for the study, as they approach AI adoption from complementary angles. While TAM explains the psychological and personal acceptance factors (perceived usefulness and ease of use), DoI highlights the social, institutional, and cultural conditions that influence how AI innovations spread within schools. Together, they illuminate how individual perceptions, collective awareness, social influence, and contextual realities determine the acceptance, utilization, and sustainability of AI-based environmental sanitation approaches in secondary schools in the North Central Zone of Nigeria. In essence, TAM clarifies why teachers and students choose to use AI solutions, whereas DoI clarifies *how* these solutions gradually integrate into school systems, routines, and practices.

2.2 Empirical Review

Several empirical studies have explored the application of artificial intelligence in education, highlighting both opportunities and challenges. Sanusi (2025) examined AI adoption among Nigerian secondary school teachers and found that most educators recognized AI's potential to personalize learning and automate administrative tasks, though infrastructural and ethical issues limited widespread adoption. Similarly, Sunday et al. (2025) reported that teachers' positive attitudes toward AI were linked to institutional support, availability of ICT tools, and access to training. Aliyu (2025) also discovered that while chemistry teachers in Sokoto State acknowledged AI's usefulness for enhancing lesson delivery, many lacked the technical skills and confidence to use such systems effectively. These studies collectively indicate that awareness, training, and resource availability are crucial determinants of AI adoption in Nigerian schools.

Internationally, similar findings have been documented. Richter (2024) found that constructivist-oriented AI integration in European classrooms improved student engagement and motivation. In Asia, Rabiatu and Shehu (2024) noted that perceived competence and access to digital infrastructure predicted teachers' attitudes toward AI-based instruction. Despite these advances, limited research has been conducted in Nigeria on how teachers and students perceive AI not just as an instructional tool but as a mechanism for addressing environmental sanitation challenges.

Artificial intelligence has been applied increasingly in environmental management and sustainability programmes worldwide. Nwokediegwu et al. (2024) reviewed AI-driven waste management systems and observed that machine-learning and IoT technologies have optimized waste collection, recycling, and energy recovery in several African cities.

Similarly, Ofem (2024) emphasized the role of AI in promoting sustainable development goals through data-driven decision-making and real-time monitoring of waste-disposal systems. In Nigeria, projects such as smart-bin initiatives and AI-assisted waste routing demonstrate potential for reducing environmental pollution and improving hygiene (Fuqaha, 2025). However, these studies are largely municipal or industrial; there is a scarcity of empirical data on integrating AI for sanitation in educational institutions. This gap emphasized the need to understand how teachers and students perceive AI solutions that could support school sanitation programmes. Therefore, the current study seeks to fill this gap by empirically investigating the perceptions, attitudes, and perceived barriers influencing the acceptance of AI-based environmental sanitation approaches in secondary schools within Nigeria's North-Central zone.

3 Materials and Methods

3.1 Study Area

The North Central Zone of Nigeria, also called the Middle Belt, consists of Benue, Kogi, Kwara, Nasarawa, Niger, Plateau States, and the Federal Capital Territory (FCT) Abuja (Figure 1). The zone lies centrally between the North and South and features savanna vegetation, the Niger–Benue River basins, and elevations such as the Jos Plateau that influence population distribution and development. This study focuses on FCT Abuja, Niger State, and Nasarawa State. Abuja represents an urban and technologically exposed environment, Niger State reflects mixed rural–urban settings, and Nasarawa State offers a developing context where technology adoption is gradually emerging.

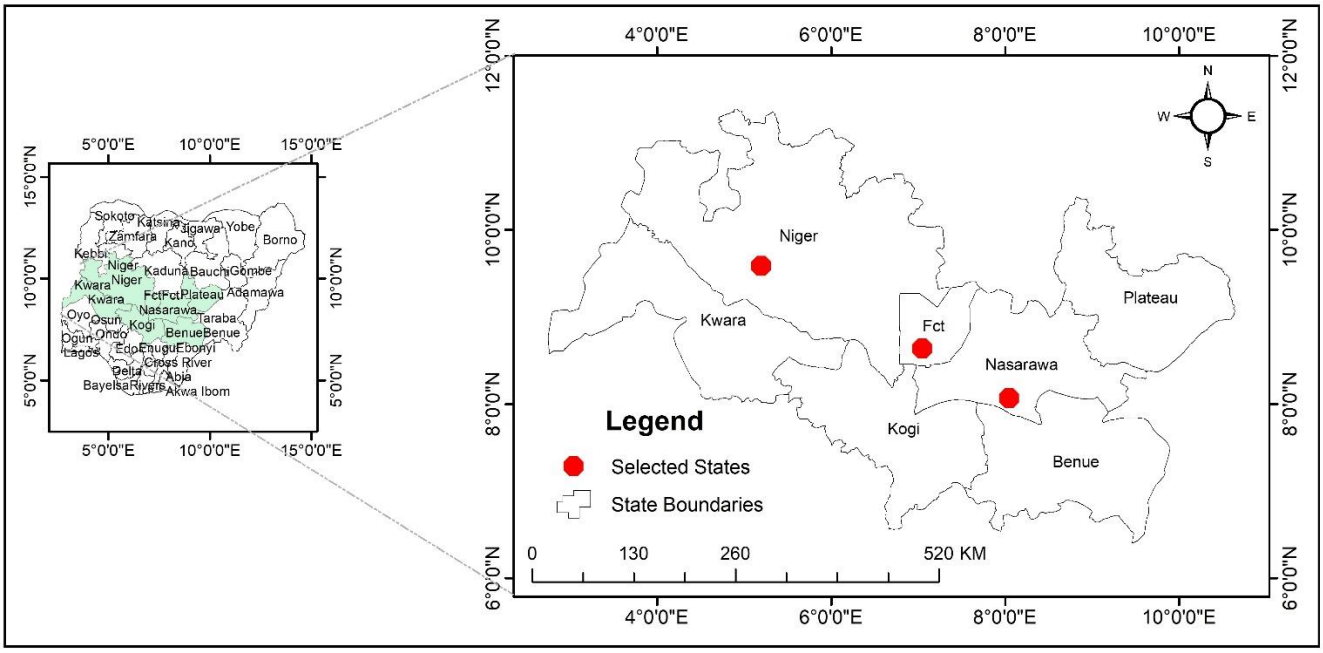

Figure 1: Map of North Central Zone, Showing the Study Area.

3.2 Research Design

The study adopted a descriptive survey research design, which was suitable for collecting quantitative data on teachers' and students' perceptions of artificial intelligence (AI)-based approaches to environmental sanitation in secondary schools within Nigeria's North Central Zone. The design enabled the researcher to capture existing attitudes and levels of awareness without manipulating variables, while also allowing for hypothesis testing between the two respondent groups.

3.3 Population of the study

The population comprised all teachers and students in public secondary schools across the North Central Zone of Nigeria, which includes the Federal Capital Territory (FCT), Niger, and Nasarawa States. According to the Federal Ministry of Education (2024), the zone has an estimated 161,020 individuals (8,420 teachers and 152,600 students). This population provided a sufficient base for investigating perceptions of AI-driven sanitation practices in schools.

3.4 Sample size and sample techniques

A multi-stage sampling technique was employed. In the first stage, three states-FCT Abuja, Niger, and Nasarawa states were purposively selected based on accessibility and educational technology activity. In the second stage, thirty secondary schools were randomly chosen (ten per state). Stratified random sampling was then used to draw proportionate numbers of teachers and students from each school to reflect the study's dual focus. Using the Taro Yamane formula, a total of 400 respondents (150 teachers and 250 students) were selected as the study sample, ensuring representativeness and manageability for data collection and analysis.

3.5 Instrumentation for Data Collection

Data were collected using a structured questionnaire titled "Teachers' and Students' Perceptions of Artificial Intelligence-Based Environmental Sanitation Questionnaire (TSP-AIBESQ)". The instrument was designed to capture teachers' and students' views on the use of AI for promoting environmental sanitation in secondary schools. It comprised teachers' perceptions, students' perceptions, institutional readiness, and practical AI-based sanitation practices such as smart bins and predictive systems. All items were rated on a four-point Likert scale of Strongly Agree (4), Agree (3), Disagree (2), and Strongly Disagree (1).

3.6 Validation and Reliability of the Instrument

The instrument was validated through expert review and reliability testing. Two specialists, one each in Educational Technology and Environmental Education from the University of Abuja, assessed the questionnaire for clarity, relevance, and adequacy in measuring the study variables. Their feedback was used to refine the items for improved validity. To ensure reliability, a pilot test was conducted with 30 respondents (15 teachers and 15 students) from two secondary schools in Niger State, not included in the main study. Using Cronbach's Alpha, a reliability coefficient of **0.84** was obtained, confirming the instrument's internal consistency and suitability for the main research.

3.7 Method of Data Collection

Data were collected by the researcher with the assistance of trained research assistants. The assistants were briefed on the objectives of the study and the administration procedures. Questionnaires were personally distributed to respondents during school hours after obtaining

permission from the respective school authorities. Respondents were assured of confidentiality and informed that their participation was voluntary. The entire data collection process lasted for approximately two weeks.

3.8 Method of Data Analysis

Data were analyzed using descriptive and inferential statistics. Mean and standard deviation were used to answer the research questions, with a decision benchmark of 2.50 and above indicating agreement. The t-test and ANOVA were employed to test the hypotheses at a 0.05 level of significance to determine the differences in perceptions between teachers and students as well as among schools or states. Ethical considerations were observed throughout the process, as participants gave informed consent before completing the instruments, and all responses were kept confidential and used strictly for academic purposes.

4 Results and Discussion

Research Question 1: What is the level of awareness of teachers and students concerning artificial intelligence-based approaches to environmental sanitation in secondary schools in the North Central Zone of Nigeria?

Table 1: Mean and Standard Deviation of Teachers' and Students' Responses on Level of Awareness of AI-Based Environmental Sanitation

S/n	Items	TEACHERS			STUDENTS		
		Mean ($\bar{x}$)	Std. Dev. (σ)	Decision	Mean ($\bar{x}$)	Std. Dev. (σ)	Decision
1	I am aware of artificial intelligence and its relevance to school sanitation.	3.18	0.81	Agree	3.02	0.85	Agree
2	I have seen or read about AI technologies used for sanitation (e.g., smart bins, sensors).	3.05	0.89	Agree	2.94	0.91	Agree
3	My school promotes awareness of modern AI-driven sanitation initiatives.	2.76	0.95	Agree	2.65	0.93	Agree
4	I understand how AI can improve waste management and hygiene in schools.	3.12	0.88	Agree	3.00	0.86	Agree
5	There are discussions or lessons in my school about the role of AI in environmental protection.	2.58	0.97	Agree	2.52	0.94	Agree

The findings in Table 1 show that both teachers and students demonstrated a high level of awareness regarding artificial intelligence (AI)-based approaches to environmental sanitation in secondary schools across the North Central Zone of Nigeria. The mean scores for all items ranged between 2.52 and 3.18 for teachers and 2.52 and 3.02 for students, all exceeding the decision benchmark of 2.50. This indicates general agreement that respondents are aware of AI and its potential application to sanitation management in schools. However, awareness appeared slightly higher among teachers than students, particularly in understanding AI's role in improving waste management and hygiene. The relatively lower mean scores on items relating to institutional promotion of AI awareness and classroom discussions suggest that while personal knowledge of AI exists, structured educational initiatives on AI-based sanitation remain limited.

Research Question 2: What are the attitudes of teachers and students toward the use of artificial intelligence-based approaches in promoting environmental sanitation in secondary schools in the North Central Zone of Nigeria?

Table 2: Mean and Standard Deviation of Teachers' and Students' Responses on Attitudes Toward AI-Based Environmental Sanitation

S/n	Items	TEACHERS Mean ($\bar{x}$)	Std. Dev. (σ)	Decision	STUDENTS Mean ($\bar{x}$)	Std. Dev. (σ)	Decision
1	I believe AI can enhance environmental cleanliness in schools.	3.34	0.78	Agree	3.28	0.81	Agree
2	Integrating AI in sanitation is an innovative step toward better hygiene.	3.41	0.75	Agree	3.35	0.79	Agree
3	I am willing to support AI-based sanitation initiatives in my school.	3.29	0.83	Agree	3.20	0.85	Agree
4	I feel AI may replace human responsibility in sanitation.	2.28	0.92	Agree	2.22	0.90	Agree
5	The use of AI aligns with sustainable environmental practices in schools.	3.25	0.86	Agree	3.17	0.84	Agree

Table 2 reveals that both teachers and students exhibited positive attitudes toward the use of AI in promoting environmental sanitation in schools. The mean scores for teachers ranged between 2.28 and 3.41 and for students between 2.22 and 3.35, showing general agreement across all items. Respondents strongly believed that AI could enhance school cleanliness, improve hygiene, and align with sustainable environmental practices. Nonetheless, both groups expressed slight concern that AI might replace human responsibility in sanitation (means: teachers = 2.28; students = 2.22), indicating mild apprehension toward automation in a socially oriented school environment. Overall, the results reflect optimism and readiness among teachers and students to embrace AI-driven sanitation innovations.

Research Question 3: What are the perceived barriers affecting the adoption and utilization of artificial intelligence-based environmental sanitation approaches in secondary schools in the North Central Zone of Nigeria?

Table 3: Mean and Standard Deviation of Teachers' and Students' Responses on Barriers to AI-Based Environmental Sanitation

S/n	Items	TEACHERS Mean ($\bar{x}$)	Std. Dev. (σ)	Decision	STUDENTS Mean ($\bar{x}$)	Std. Dev. (σ)	Decision
1	Lack of funds limits the introduction of AI-based sanitation in schools.	3.46	0.72	Agree	3.39	0.76	Agree
2	Insufficient technical skills among teachers hinder AI adoption.	3.38	0.79	Agree	3.25	0.81	Agree
3	Poor electricity and internet connectivity discourage AI use.	3.44	0.74	Agree	3.32	0.78	Agree
4	Limited awareness and training opportunities affect AI integration.	3.29	0.82	Agree	3.21	0.84	Agree
5	School management shows little commitment to adopting AI for sanitation.	3.17	0.85	Agree	3.09	0.87	Agree

The results presented in Table 3 highlight several key barriers limiting the adoption and utilization of AI-based sanitation practices in schools. Both teachers and students agreed that lack of funds, insufficient technical skills, and poor electricity and internet connectivity were the most critical challenges, with mean scores above 3.30 for both groups. Other notable barriers included limited training opportunities and weak administrative support for AI integration.

These findings suggest that infrastructural and capacity-related constraints pose significant obstacles to implementing AI-driven environmental sanitation programmes in secondary schools. Teachers and students share a common understanding that effective adoption requires improved funding, technical training, and stronger institutional commitment.

4.1 Test of Hypotheses

The t-test analysis (Table 4) examined whether teachers and students differed significantly in their level of awareness regarding AI-based environmental sanitation. The computed t-value (1.42) was less than the critical value (1.96) at a 0.05 significance level (p = 0.16). This indicates that there was no significant difference between the two groups. Both teachers and students therefore possess comparable awareness levels of AI applications to sanitation, implying a fairly uniform exposure to AI-related knowledge across school communities in the North Central Zone.

Table 4: t-test Analysis of the Difference in Awareness Levels between Teachers and Students Regarding AI-Based Environmental Sanitation.

Groups	Mean	Std. Dev	N	Df	t-test	t-crit	Sig. (2-tailed)
Teachers	2.94	0.88	150	398	1.42	1.96	0.16
Students	2.83	0.90	250				

The correlation analysis in Table 5 shows that both teachers (r = 0.218) and students (r = 0.214) exhibited positive but weak relationships between their attitudes and the utilization of AI-based sanitation approaches. Since the computed correlation coefficients were lower than the critical value (r = 0.195) and the significance level (p = 0.07) exceeded 0.05, the result implies no statistically significant relationship. This suggests that although teachers and students generally hold favorable attitudes toward AI, these attitudes do not necessarily translate into active utilization or implementation of AI technologies in sanitation activities, possibly due to infrastructural and financial limitations highlighted earlier.

Table 5: Correlation Analysis of the Relationship between Attitudes and Utilization of AI-Based Environmental Sanitation

Variables	N	r-cal	r-crit	Sig. (2-tailed)
Teachers' Attitude and Utilization	150	0.218	0.195	0.07
Students' Attitude and Utilization	250	0.214	0.195	0.07

The correlation analysis in Table 5 shows that both teachers (r = 0.218) and students (r = 0.214) exhibited positive but weak relationships between their attitudes and the utilization of AI-based sanitation approaches. Since the computed correlation coefficients were lower than the critical value (r = 0.195) and the significance level (p = 0.07) exceeded 0.05, the result implies no statistically significant relationship. This suggests that although teachers and students generally hold favorable attitudes toward AI, these attitudes do not necessarily translate into active utilization or implementation of AI technologies in sanitation activities, possibly due to infrastructural and financial limitations highlighted earlier.

Table 6: ANOVA Summary of the Influence of Perceived Barriers on AI-Based Environmental Sanitation Adoption

Source of Variation	Sum of Squares	Df	Mean Square	F-cal	F-crit	Sig. (2-tailed)
Between Groups	4.26	2	2.13	2.11	3.02	0.12
Within Groups	400.78	397	1.01			
Total	405.04	399				

Table 6 shows that the calculated F-value (2.11) is lower than the critical value (3.02) at p = 0.12, indicating no significant influence of perceived barriers on the adoption of AI-based environmental sanitation. This means that teachers and students across schools experience similar challenges, such as limited funds, poor infrastructure, and inadequate skills, which equally affect AI adoption. Hence, the null hypothesis (H_{03}) is retained.

5 Discussion of Findings

The high levels of awareness of AI-based environmental sanitation observed among both teachers and students indicate a foundational readiness for adopting technology in school sanitation systems. However, the slightly higher awareness among teachers suggests that professional exposure and experience may give them a better understanding of AI applications. Importantly, the finding that institutional support and structured AI education remain limited highlights a critical gap: awareness alone does not guarantee effective adoption. This emphasized the role of schools and education authorities in creating enabling environments that translate knowledge into practice, reinforcing Sanusi's (2025) assertion that classroom-level AI integration is constrained by infrastructural and capacity gaps. Similarly, Sunday et al. (2025) emphasize that while

awareness is necessary, practical opportunities to engage with AI tools are crucial for meaningful adoption.

Positive attitudes toward AI adoption suggest that teachers and students recognize the potential benefits of AI in enhancing school sanitation. The slight apprehension regarding AI replacing human roles, though statistically non-significant, is conceptually important. It indicates that even when participants show general optimism, concerns about job security, ethical implications, and trust in technology can influence the sustainability of AI implementation. This finding aligns with Adeleke and Olatunji (2023), who note that perceived alignment with human roles shapes acceptance, and Okafor et al. (2024), who emphasize trust and transparency as critical factors. Thus, non-significant differences in attitude between teachers and students are meaningful: they reveal a broadly similar optimism but also point to underlying caution that must be addressed through policy and awareness campaigns.

The systemic barriers identified, including funding deficits, limited technical skills, unreliable electricity and internet connectivity, and inadequate administrative support, explain why positive awareness and attitudes may not translate into effective AI adoption. These non-significant differences across respondents reinforce that infrastructure and institutional readiness, rather than individual perception, are the primary limiting factors. This confirms the findings of Nwokediegwu et al. (2024) and Balogun-Adeleye et al. (2021), emphasizing that without addressing these structural challenges, AI interventions in school sanitation are unlikely to achieve their intended impact. In essence, the results highlight that fostering both technological readiness and supportive institutional environments is essential for bridging the gap between positive perceptions and actual implementation of AI-based sanitation practices in Nigerian secondary schools.

6 Conclusion

The study examined teachers' and students' perceptions of artificial intelligence (AI)-based approaches to environmental sanitation in secondary schools across the North Central Zone of Nigeria. Findings revealed a generally high level of awareness and positive attitudes toward the integration of AI in sanitation management. Both teachers and students recognized AI's potential to enhance cleanliness, hygiene, and sustainability within school environments. However, major barriers such as inadequate funding, poor infrastructure, limited technical skills, and a lack of institutional support were identified as constraints to effective implementation. Statistical analysis further showed no significant difference between teachers' and students' awareness levels and no significant relationship between attitudes and actual utilization of AI-based sanitation practices. This suggests that while knowledge and interest in AI exist, practical adoption remains weak due to systemic challenges.

To address these issues, it is recommended that regular training and workshops should be organized by the Ministry of Education in collaboration with school management, technology experts and relevant environmental agencies for teachers and students on AI applications in environmental management to strengthen technical competence and practical understanding, government and educational authorities should allocate special funds to support the deployment of AI tools such as smart bins and sensor-based sanitation systems in schools, the Nigerian Educational Research and Development Council (NERDC) in collaboration with the Federal Ministry of Education should integrate AI and environmental education concepts into the secondary school curriculum to promote awareness, innovation, and a sustainability culture among learners, the Federal Ministry of Education, through the Universal Basic Education Commission (UBEC) and State Ministries of Education, should encourage partnerships between schools, technology firms, and environmental agencies to promote innovation and provide technical support for AI-based sanitation projects, and the Ministries of Education and Environment should formulate and enforce policies that promote digital environmental practices within the school system to ensure sustainable implementation. Future studies could investigate interventions or strategies to overcome infrastructural and institutional barriers, enabling more effective adoption of AI-based sanitation practices in schools.

References

Adejumo, A., & Olayinka, T. (2022). Challenges of environmental sanitation in Nigerian public tertiary institutions. Journal of Environmental Health Research, 10(1), 45–53.

Adeleke, S. A., & Olatunji, T. A. (2023). Teachers' readiness and perception toward the integration of artificial intelligence in Nigerian secondary schools. International Journal of Education and Development Using Information and Communication Technology, 19(2), 45–58.

Adewumi, A. O., & Olatunji, T. O. (2022). Application of artificial intelligence in sustainable waste management systems in developing countries: The Nigerian experience. Journal of Environmental Management and Sustainability, 14(2), 45–58.

Aliyu, F. (2025). Teachers' awareness and perception on utilization of artificial intelligence as a tool for teaching and learning

chemistry at secondary schools in Sokoto State. Research Journal of International Studies, 3(1), 44–57.

Balogun-Adeleye, R., Abiola, A., & Agbaje-Daniels, T. (2021). Water and sanitation facilities in selected schools in Ibadan, South-western Nigeria. FUOYE Journal of Engineering and Technology, 6(3), 73–76. https://doi.org/10.46792/fuoyejet.v6i3.625

Bharadwaj, R., & Srivastava, S. (2021). Robotic technologies in environmental health: A systematic review. International Journal of Smart and Sustainable Systems, 5(2), 77–89.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly, 13(3), 319–340. https://doi.org/10.2307/249008

Eze, C. C., & Yusuf, M. O. (2024). Artificial intelligence for sustainable school management and environmental education in Nigeria: Teachers' and students' perspectives. Journal of Educational Technology and Sustainability, 6(1), 22–37.

Fuqaha, S. (2025). Artificial Intelligence and IoT for Smart Waste Management. FAITH: Future Advances in Information and Technology, 3(1), 12–28.

Igbokwe, P. C. (2024). Exploring the role of artificial intelligence in public service delivery in Anambra State, Nigeria. Advance Journal of Business and Entrepreneurship Development, 8(5), 27–35.

Luckin, R., & Cukurova, M. (2021). Designing educational technologies in the age of AI: A learning sciences-based approach. British Journal of Educational Technology, 52(4), 1659–1675. https://doi.org/10.1111/bjet.13111.

Mapcarta. (2024). Federal Capital Territory, Abuja (Nigeria). https://mapcarta.com /Federal_Capital_Territory.

Nwokediegwu, Z. Q. S., Ugwuanyi, E. D., Dada, M. A., Majemite, M. T., & Obaigbena, A. (2024). AI-driven waste management systems: A comparative review of innovations in the USA and Africa. Engineering Science and Technology Journal, 5(2), 507–516. https://doi.org/10.51594/estj.v5i2.828

Ofem, U. J. (2024). Sustainable artificial intelligence-driven classroom assessment in higher institutions: Lessons from Nigeria. EJIMed, 6(3), 202–251. https://doi.org/10.30935/ejimed/15265

Ogunyemi, B. A., Okafor, C., & Adebayo, K. (2023). University–industry collaboration for smart waste management: Emerging AI-based innovations in Nigeria. African Journal of Science, Technology, Innovation and Development, 15(4), 512–524. https://doi.org/ 10.1080/20421338.2022.2063241.

Okafor, L. C., Udeh, K. A., & Ocheni, S. I. (2024). Students' trust and attitudes toward artificial intelligence in learning environments: Evidence from North-Central Nigeria. African Journal of Contemporary Education Research, 8(3), 101–118.

Rabiatu, M. M., & Shehu, S. A. (2024). Adopting artificial intelligence (AI) in education: Challenges and possibilities. Asian Journal of Advanced Research and Reports, 18(2), 106–111. https://doi.org/10.9734/ajarr/2024/v18i2608

Richter, S., Giroux, M., Piven, I., Sima, H., & Dodd, P. (2025). A constructivist approach to integrating AI in marketing education: Bridging theory and practice. Journal of Marketing Education, 47(2), 94-111. https://doi.org/10.1177/02734753241288876

Rogers, E. (2003). Diffusion of Innovations. Fifth edition. Free Press: New York.

Sanusi, I. (2025). Artificial intelligence in school education: the case of Nigeria. Revue internationale d'éducation de Sèvres, (HS-4). https://doi.org/10.4000/146vp

Sunday, G. I., Bassey, E. J., Essien, A. E., Udoh, U. S., & Paul, U. E. (2025). Teachers' perceptions of the integration of artificial intelligence tools in classroom instruction and academic performance in secondary schools in Akwa Ibom State, Nigeria. ISIR Journal of Arts, Humanities and Social Sciences, 2(2), 57–70.

UK/WHO/UNICEF. (2020). Water, sanitation and hygiene in schools — Global baseline report 2018 (Joint Monitoring Programme for Water Supply, Sanitation and Hygiene). World Health Organization & UNICEF. https://washdata.org/reports.

United Nations Development Programme. (2024). AI for sustainable cities: Smart waste management pilot projects in Nigeria. UNDP Africa Report.