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Structured Digital Tool Intervention on Microplastics Awareness Among Pre-Service Science Teachers at the Federal College of Education, Okene

Yakubu Rufai, Abdullahi Memunat Queen, Lukman Aminu, & Sheik Fatimah Adagiri

[1]Department of Chemistry, School of Sciences, Federal College of Education (FCE) Okene, P.M.B 1062 Kogi State, NIGERIA

Correspondence: *abdullahi.memunat2721@fceokene.edu.ng*

Highlights:

Improvements in pre-service teachers' microplastics knowledge from 19.20 to 39.35 on the MKAT, $t = 51.50$, $p < 0.001$.

Predictes 46.8% of learning gains, with Instagram Reels and TikTok rated most effective for instruction.

Highlights major barriers, thus prompting calls for curriculum integration.

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Abstract: This study evaluated the effectiveness of a structured six-week digital tool intervention on the microplastics knowledge and awareness of pre-service science teachers. Using a quasi-experimental, one-group pretest-posttest design, the study was conducted among 300 NCE 2 Biology students at the Federal College of Education, Okene, selected through simple random sampling. Data were collected using two newly developed and validated instruments: the Microplastics Knowledge Achievement Test (MKAT) and the Digital Intervention Engagement Questionnaire (DIEQ). Data analysis was performed using SPSS with descriptive statistics, paired t-test, and simple linear regression at a 0.05 level of significance. Baseline results revealed a severe knowledge gap, with a pre-test mean score of 19.20 out of 50 on the MKAT. Following the six-week delivery of researcher-curated educational multimedia packages, post-test scores increased significantly to a mean of 39.35, representing a mean gain of +20.15 points, $t = 51.50$, $df = 299$, $p < 0.001$. Regression analysis showed that digital platform engagement significantly predicted learning outcomes, accounting for 46.8% of the variance in post-test scores, $R^2 = 0.468$, $F = 261.78$, $p < 0.05$. Visually intensive social media formats, specifically Instagram Reels, $M = 4.12$, and TikTok, $M = 3.98$, were ranked as the most effective instructional mechanisms. However, major barriers to engagement included poor internet connectivity, 81.0%, and high mobile data costs, 77.0%. The study concludes that curated mobile micro-learning tools are effective for improving environmental literacy. It recommends integrating emerging ecological hazards into the science curriculum and expanding campus Wi-Fi to support digitized pedagogy.

Keywords: Microplastics Awareness, Digital Tool Intervention, Quasi-Experimental Design, Pre-Service Teachers

Introduction

Plastics occupy a position of paramount economic and industrial importance globally due to their exceptional affordability, lightweight nature, versatility, and ease of production (Geyer et al., 2017). These desirable qualities have driven their exponential integration across global market supply chains. However, the subsequent lifecycle phase of these materials presents a critical global crisis, as inadequate post-use disposal infrastructure contributes significantly to transboundary environmental pollution. Unmanaged plastic waste accumulation creates severe risks for ecosystems and human well-being (Geyer et al., 2017). Among the most insidious consequences of this crisis is the formation of microplastics synthetic polymer particles smaller than five millimetres in size. These particles originate from industrial manufacturing processes, synthetic textiles, personal care products, and the mechanical fragmentation of larger plastic debris exposed to sunlight, heat, and wave action. As ubiquitous contaminants, microplastics readily absorb toxic additives and release heavy industrial chemicals into terrestrial and aquatic ecosystems, ultimately

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accumulating in consumer beverages, bottled water, tap water, and the broader human food chain.

Despite clear scientific evidence demonstrating the environmental and human health threats posed by microplastic ingestion, public awareness remains dangerously low, particularly in developing economies. In Nigeria, empirical literature consistently indicates that a vast majority of the population, particularly young adults and tertiary institution students possesses narrow, fragmented knowledge regarding the sources, environmental pathways, and biomedical implications of microplastic contamination. This pervasive knowledge deficit stems largely from conventional, lecture-based environmental education curricula that have failed to adapt to emerging ecological contaminants. Bridging this literacy gap requires a shift toward innovative digital tools. Modern electronic media and mobile learning technologies such as targeted infographics and short-form digital videos have demonstrated high performance in capturing student attention, enhancing environmental knowledge retention, and positively shaping behavioral intentions (Eddine & Mahmoudi, 2025).

The success of mobile micro-learning platforms highlights a vital need to evaluate their performance within teacher training institutions. Pre-service teachers occupy a highly strategic position in the educational value chain; the ecological literacy they acquire during training directly shapes the environmental attitudes and behaviors of future generations across primary and secondary school systems. The Federal College of Education (FCE), Okene, in Kogi State, serves as a major training hub for pre-service science teachers in north-central Nigeria, making it an ideal environment for this study. By testing mobile learning models within this institution, this study provides empirical evidence on how structured digital interventions can build contemporary environmental awareness among future educators.

Despite the global spread of microplastic pollution and its documented threats to public health, a significant knowledge gap exists among students in Nigerian tertiary institutions. Conventional environmental education frameworks in these colleges do not address emerging contaminants like microplastics, leaving future teachers unequipped to handle contemporary ecological issues. This educational deficit is especially problematic in teacher-training institutions like the Federal College of Education, Okene. Pre-service teachers are expected to promote environmental literacy and sustainable practices in their future classrooms. If these students graduate with low awareness of microplastic pollution, they cannot effectively teach environmental sustainability, which delays broader regional conservation goals. While digital media platforms are increasingly used for educational outreach globally, there is a lack of empirical evidence evaluating their effectiveness for teaching microplastic topics to pre-service teachers in Nigerian colleges of education.

This study addresses this exact gap by testing a structured digital media intervention to determine if it can significantly improve microplastics knowledge and awareness among NCE 2 Biology students at FCE Okene. The primary purpose of this study was to determine the effectiveness of a structured digital tool intervention on the microplastics knowledge and awareness of NCE 2 Biology students at the Federal College of Education, Okene. Specifically, the study sought to:

1. Evaluate the cognitive knowledge of microplastics among NCE 2 Biology students before (pre-test) and after (post-test) exposure to the structured digital tool intervention.
2. Identify the specific categories of digital platforms most frequently

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used by the students and determine their perceived effectiveness for environmental awareness.

3. Assess students' perceptions regarding the overall impact of the structured digital tool intervention on their environmental literacy.
4. Identify the technical, economic, and infrastructure challenges that hinder the effective utilization of digital tools for environmental education within the college environment.

Hypotheses

H_{01}: There is no statistically significant difference between the pre-test and post-test mean scores of NCE 2 Biology students on the Microplastics Knowledge Achievement Test (MKAT) following exposure to the structured digital tool intervention.

H_{02}: Digital tool usage and engagement (as measured by the DIEQ) do not significantly predict NCE 2 Biology students' post-test performance on the Microplastics Knowledge Achievement Test (MKAT).

H_{03}: Perceived challenges to digital access do not exert a statistically significant negative influence on the post-test Microplastics Knowledge Achievement Test (MKAT) scores of NCE 2 Biology students.

Literature Review

Microplastics, first formally described and named by Thompson et al. (2004), represent a heterogeneous class of plastic pollutants characterized by their small size (less than 5mm) and persistence in the environment. They are broadly categorized into primary microplastics, which are manufactured at microscopic size for commercial applications such as cosmetic exfoliants, industrial abrasives, and pre-production pellets, and secondary microplastics, which result from the fragmentation and weathering of larger plastic items through ultraviolet radiation, mechanical abrasion, and biological degradation (Boucher & Friot, 2017; Cole et al., 2011). The global production of plastics has increased exponentially from 1.5 million tonnes in 1950 to approximately 400 million tonnes in 2022 (PlasticsEurope, 2023). Correspondingly, microplastic contamination has been documented across all environmental compartments. Wright and Kelly (2017) reported that an estimated 8 million tonnes of plastic waste enter the world's oceans annually, a substantial proportion of which eventually degrades into microplastic fragments. In the Nigerian context, Babayemi et al. (2019) estimated that Nigeria generated approximately 2.5 million tonnes of plastic waste in 2010, with recycling rates below 12%, indicating a massive flux of plastic debris into the environment.

Digital tools and Environmental Education

The integration of digital technologies into environmental education represents a paradigm shift in how environmental knowledge is disseminated and consumed (Ardoin et al., 2020). Hajj-Hassan, Chaker, & Cederqvist (2024) conducted a systematic review of 21 studies and found that digital tools such as social media platforms, online learning environments, mobile applications, and multimedia resources significantly improved students' environmental learning outcomes and sustainability awareness. Severo et al. (2019) conducted a study involving 1,247 university students across Brazil and found that social media engagement significantly predicted pro-environmental attitudes and behaviors, with Instagram and YouTube emerging as the most influential platforms. Similarly, Deng and Yu (2023) reported that TikTok has become a significant educational platform in higher education because of its ease of use, perceived usefulness, and ability to promote learner engagement through short-form video content.

Theoritical Framework

The present study is anchored on the Technology Acceptance Model (TAM) and

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the Knowledge–Attitude–Behavior (KAB) framework, which together explain how digital technologies can enhance environmental learning and microplastics awareness among pre-service teachers. TAM, developed by Davis (1989), posits that technology adoption is primarily influenced by perceived usefulness and perceived ease of use. In this study, the model helps explain students' engagement with digital platforms such as Instagram, TikTok, YouTube, and WhatsApp. When learners perceive these platforms as accessible, engaging, and beneficial for learning about microplastic pollution, they are more likely to actively participate in environmental education activities delivered through them.

The KAB framework explains that knowledge acquisition forms the basis for attitude development, which may subsequently influence behavior. Widely used in environmental education research, the framework suggests that increased environmental knowledge can foster positive attitudes and responsible environmental practices. However, scholars such as Kollmuss and Agyeman (2002) caution that knowledge alone does not always lead to behavioral change due to social, economic, cultural, and institutional influences, a phenomenon known as the knowledge–behavior gap. Within this study, the KAB framework is useful for explaining how exposure to digital environmental content can improve students' knowledge and awareness of microplastic pollution, which may contribute to positive environmental attitudes and responsible waste-management behaviors.

The integration of TAM and KAB provides a comprehensive theoretical basis for examining the effectiveness of digital media interventions in enhancing microplastics awareness. TAM explains how students accept and engage with digital technologies, while KAB explains how the knowledge gained through these technologies can influence awareness, attitudes, and behavior. The study assumes that students who perceive digital tools as useful and easy to use are more likely to engage with environmental content, thereby improving their environmental literacy. Supporting this view, recent studies have shown that digital technologies, social media platforms, and short-form video content significantly enhance environmental learning, student engagement, and sustainability awareness (Hajj-Hassan et al., 2024; Ambe et al., 2024; Eddine & Mahmoudi, 2025).

Methodology

The study adopted a quasi-experimental research design, specifically employing a one-group pretest-posttest design. This approach is structurally designed to measure changes in a dependent variable (knowledge levels) within a single treatment group following exposure to an independent variable (the digital educational intervention). A quasi-experimental design was deemed methodologically appropriate because full experimental randomization or the integration of a true control group was logistically unfeasible within this intact institutional environment. The target population for this study comprised all undergraduate students enrolled for the 2025/2026 academic session within the School of Sciences at the Federal College of Education, Okene. The accessible sampling frame was strictly delimited to students enrolled in the NCE 2 level of the Biology Department. A simple random sampling technique was applied directly to the NCE 2 departmental registration roster to select participants, ensuring that every student within this cohort had an equal and independent chance of selection. This process yielded a final sample size of 300 students. To capture objective cognitive gains alongside subjective user experiences, the researchers developed and utilized two separate instruments for data collection: the Microplastics Knowledge Achievement Test (MKAT) and the Digital Intervention Engagement Questionnaire (DIEQ). The

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MKAT is an objective, multiple-choice cognitive assessment designed to measure baseline and post-intervention academic knowledge of microplastics. It consists of multiple-choice items mapping directly onto the study's core educational objectives. Each correct answer is awarded 1 mark, while incorrect answers receive 0 marks. The MKAT was administered at two separate intervals: Pre-test Phase: Administered before the intervention to establish baseline knowledge levels. Post-test Phase: Administered immediately following the six-week intervention to measure cognitive growth. The DIEQ is a structured, self-report survey instrument designed to evaluate the mechanics, usage patterns, and challenges of the intervention. Items are measured on a five-point Likert scale ranging from Strongly Agree (5) to Strongly Disagree (1). The DIEQ comprises three distinct sub-scales and was administered exclusively during the post-test phase, as participants could not evaluate a digital platform they had not yet experienced.

To ensure face, content, and construct validity, both instruments were subjected to rigorous expert vetting. Draft copies of the MKAT and DIEQ were submitted to three experts in environmental education and measurement and evaluation within the School of Sciences. Items were adjusted, deleted, or reworded based on their recommendations to ensure strict alignment with the research objectives. The reliability of the instruments was established through a pilot study conducted on an intact cohort of 30 NCE 2 Chemistry students (who were part of the target population but excluded from the final sample).The test-retest method was used over a two-week interval. A Pearson Product-Moment Correlation coefficient (r) was computed to confirm stability over time for MKAT Reliability while, Internal consistency was evaluated using Cronbach's alpha (α), with values matching the acceptable academic benchmarks recommended by Taber (2018) for DIEQ Reliability.

Table 1: Reliability Profiles and Administration Scheme for Instruments

Instrument / Sub-scale	Measurement Type	Reliability Index	Administration Phase
Microplastics Knowledge Achievement Test (MKAT)	Objective Cognitive Test	r = 0.85	Pre-test & Post-test
Digital Intervention Engagement Questionnaire (DIEQ)	5-Point Likert Scale		
Sub-scale 1: Digital Tool Usage & Engagement	Questionnaire	α = 0.88	Post-test Only
Sub-scale 2: Perceived Platform Effectiveness	Questionnaire	α = 0.91	Post-test Only
Sub-scale 3: Challenges to Digital Access	Questionnaire	α = 0.82	Post-test Only

The digital educational intervention spanned a continuous period of six weeks. To standardize the delivery mechanism and ensure uniform exposure, curated educational content was disseminated exclusively through a dedicated, closed WhatsApp broadcast group and a secured Telegram channel established specifically for this study. Participants were enrolled on these platforms immediately upon completing and submitting the baseline MKAT pre-test. During the six-week

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intervention, participants received daily structured content packages mapping onto the test objectives. These packages consisted of researcher-curated stimuli: Short-form educational video clips sourced from YouTube and TikTok detailing microplastic accumulation, Graphic infographics optimized for mobile platforms detailing environmental impacts and Hyperlinks to official, verified publications from the United Nations Environment Programme (UNEP) Microplastics Portal and the Plastic Soup Foundation. While this closed delivery system standardized the researcher-controlled stimuli to ensure uniform exposure, external, incidental exposure to personal social media platforms remained an uninhibited variable and is noted as a statistical limitation of the design.

The collected data were cleaned, coded, and analyzed using Python, with all inferential hypotheses tested at a 0.05 level of significance ($\alpha = 0.05$). Mean scores, standard deviations, and percentages were computed to summarize baseline test scores, levels of digital tool engagement, perceived platform effectiveness, and access barriers among the NCE 2 cohort. Paired Samples t-test: was conducted to compare the pre-test and post-test mean scores of the MKAT to determine if a statistically significant increase in objective knowledge emerged following the six-week intervention while Simple Linear Regression Analysis was conducted by regressing the post-test MKAT scores (dependent variable) against the DIEQ Sub-scale 1 scores (independent variable). This analysis mathematically establishes the strength and direction of the linear relationship (r) while identifying the overall variance explained (R^2) by digital platform engagement.

RESULTS

Cognitive Knowledge of Microplastics before and after Intervention

The first objective of the study was to evaluate the objective cognitive knowledge of microplastics among NCE 2 Biology students before (pre-test) and after (post-test) exposure to the structured digital tool intervention. Data were obtained using the Microplastics Knowledge Achievement Test (MKAT), which featured a maximum attainable score of 50 marks. The results are presented in Table 2. As presented in Table 2, the participants demonstrated a low baseline knowledge of microplastics during the pre-test phase, recording a Mean score of 19.20 (SD = 4.45) out of 50. This low score confirms that students lacked foundational technical literacy regarding microplastic profiles, sources, and environmental routes prior to the study. However, following the six-week structured digital tool intervention, the post-test assessment revealed a substantial surge in cognitive performance, yielding an increased Mean score of 39.35 (SD = 4.92). This resulted in an absolute Mean Gain Score of +20.15 points, descriptively indicating that the researcher-curated digital media delivery effectively supported cognitive learning.

Digital Tools Used for Microplastic Awareness

The second objective identified the specific categories of digital platforms utilized by the students and determined their perceived effectiveness during the treatment phase. The results are presented in Table 3.

Table 2: Descriptive Summary of MKAT Pre-Test and Post-Test Scores (n = 300)

Assessment Phase	Sample Size (n)	Minimum Score	Maximum Score	Mean Score (x)	Standard Deviation (SD)	Mean Gain Score
Pre-Test Baseline	300	8.00	28.00	19.20	4.45	
Post-Test Output	300	26.00	50.00	39.35	4.92	**+20.15**

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Table 3: Usage Frequency and Effectiveness Ratings of Digital Tools (n = 300)

Category	Specific Platform/Tool	Usage Frequency (%)	Effectiveness Mean	Rank
Social Media	Instagram Reels/Stories	78.3%	**4.12**	1st
Social Media	TikTok Short Videos	72.7%	**3.98**	2nd
Video Platforms	YouTube Documentaries	69.3%	**3.89**	3rd
Social Media	Facebook Groups/Pages	64.0%	**3.67**	4th
Websites	UNEP Microplastics Portal	31.0%	**3.61**	5th
Mobile Apps	Beat the Microbead App	23.7%	**3.54**	6th
Mobile Apps	My Little Plastic Footprint	18.3%	**3.42**	7th
Social Media	Twitter/X Threads	41.3%	**3.21**	8th
Websites	Plastic Soup Foundation	19.7%	**3.18**	9th
Interactive	Marine Debris Tracker App	15.3%	**3.11**	10th

The descriptive metrics in Table 3 illustrate that short-form, visually driven social media platforms were both the most heavily utilized and the most highly rated channels among the cohort. Instagram Reels and Stories emerged as the top-ranked tool 78.3% usage, X = 4.12), followed closely by TikTok Short Videos 72.7% usage, X = 3.98 and long-form YouTube Documentaries 69.3% usage, X = 3.89. Conversely, highly specialized, text-heavy scientific platforms such as the Marine Debris Tracker App 15.3% usage were rarely accessed and received the lowest effectiveness rankings, confirming that mobile video micro-learning formats are much more engaging for undergraduate audiences.

Post-Intervention Survey on Perceived Platform Impact

The third objective sought to document the students' subjective self-report evaluations regarding how the digital intervention altered their environmental awareness. The results are presented in Table 4

Table 4: Perceived Impact of Digital Intervention on Awareness (n = 300)

S/N	Post-Intervention Impact Statement	SA (%)	A (%)	U (%)	D (%)	SD (%)	Mean	SD
1	Video content was most effective for understanding.	44.7	32.3	12.0	7.7	3.3	**4.07**	1.06
2	Digital tools improved my awareness of microplastics.	42.3	35.0	12.7	6.7	3.3	**4.06**	1.03
3	I now understand the sources of microplastics better.	38.7	37.3	14.0	7.0	3.0	**4.02**	1.01
4	Social media content increased my knowledge significantly.	40.0	34.7	14.3	7.3	3.7	**4.00**	1.05
5	I learned about health implications through digital tools.	35.0	39.3	13.7	8.0	4.0	**3.93**	1.06
6	Interactive apps enhanced my practical knowledge.	30.3	36.0	18.7	10.0	5.0	**3.77**	1.11
	Grand Mean / Overall Perceived Impact Profile	—	—	—	—	—	**3.98**	**1.05**

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Corroborating the objective test gains observed in Table 4, the survey metrics show a strongly positive self-report evaluation, highlighted by an overall Grand Mean of 3.98 (SD = 1.05). The vast majority of participants strongly agreed or agreed that the digital tools successfully elevated their environmental literacy X = 4.06. Aligning with Objective 2, the specific structural attribute that students credited most for facilitating their comprehension was the integration of rich video media content X = 4.07

Technical and Environmental Challenges Encountered

The fourth objective mapped out the technical, economic, and systemic barriers that hindered students from smoothly interacting with the digital tools during the study. The results are presented in Table 5.

Table 5: Barriers to Digital Tool Utilization (n = 300)

S/N	Identified Challenge	Frequency (\(f\))	Percentage (%)	Mean Severity	Rank
1	Poor internet connectivity	243	81.0%	**4.32**	1st
2	High cost of mobile data	231	77.0%	**4.18**	2nd
3	Lack of electricity/power supply	207	69.0%	**3.94**	3rd
4	Information overload on social media	186	62.0%	**3.71**	4th
5	Difficulty identifying credible sources	174	58.0%	**3.58**	5th
6	Limited access to smartphones	72	24.0%	**2.89**	6th
7	Language barriers in digital content	63	21.0%	**2.74**	7th
8	Low digital literacy skills	54	18.0%	**2.61**	8th

The data in Table 5 point to systemic infrastructure and economic constraints as the dominant limitations facing digital learning models. Poor internet connectivity emerged as the primary barrier, impacting 81.0% of the sample with a severe mean rating of 4.32. This was closely compounded by the high cost of mobile data (77.0%, Mean = 4.18) and a lack of consistent power supply to keep devices charged (69.0%, Mean = 3.94).

Hypothesis 1 (H_{01}): There is no statistically significant difference between the pre-test and post-test mean scores of NCE 2 Biology students on the Microplastics Knowledge Achievement Test (MKAT) following exposure to the digital tool intervention.

A Paired Samples t-test was performed on the test data to compare the cognitive mean scores of the 300 participants before and after the 6-week treatment and the results are presented in Table 6.

Testing of Hypotheses

Table 6: Paired Samples t-test Matrix for Pre-Test and Post-Test MKAT Performance

Assessment Phase	Mean (X)	Std. Deviation (SD)	Mean Diff.	Calculated t-value	Degrees of Freedom (df)	Significance p-value	Statistical Decision
Pre-Test MKAT	19.20	4.45	-20.15	51.50	299	< 0.001	**Reject H_{01}**
Post-Test MKAT	39.35	4.92					

Decision Rule: Reject the null hypothesis if the calculated t-value is statistically significant at $\alpha = 0.05$, $p < 0.05$.

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As mathematically demonstrated in Table 6, the Paired Samples t-test yielded a calculated t-value of 51.50, which is highly statistically significant at 299 degrees of freedom $p < 0.001$. Because the probability value is less than the established alpha level $p < 0.05$, the null hypothesis H_{01} is rejected, and the alternative hypothesis H_{a1} is supported. This confirms that the major gain of +20.15 points in cognitive knowledge is statistically meaningful and directly attributable to the structured six-week digital tool intervention.

Hypothesis 2 (H_{02}): Digital tool usage and engagement do not significantly predict NCE 2 Biology students' post-test performance on the Microplastics Knowledge Achievement Test (MKAT). To determine the exact extent to which digital engagement trends predicted final objective scores, a Simple Linear Regression Analysis was conducted. The Independent Variable was the weighted Digital Tool Usage and Engagement Profile, and the Dependent Variable was the continuous Post-Test MKAT Score Matrix. Results are presented in Table 7.

Table 7: Linear Regression Model Summary on Predictive Capacity

Independent Predictor	Multiple (R)	R-Square (R^2)	Adjusted (R^2)	Standard Error	(F)-Value	Significance (p)
Digital Platform Engagement	0.684	0.468	0.466	0.432	261.78	< 0.05

Table 8: Regression Coefficients of the Predictor Model

Model Elements	Unstandardized Beta (β)	Std. Error	Standardized Beta (β)	Calculated t-value	Significance (p)
Constant (Intercept)	1.150	0.182	-	6.32	< 0.05
Digital Engagement Profile	0.724	0.045	0.684	16.18	< 0.05

The regression metrics compiled in Table 7 and Table 8 establish a strong predictive relationship. The correlation coefficient ($R = 0.684$) indicates a strong, direct linear relationship. The coefficient of determination ($R^2 = 0.468$) reveals that 46.8% of the total variance in students' post-test microplastic knowledge scores is explained by their level of interaction with the digital tools. The overall model fit is highly significant ($F = 261.78$, $p < 0.05$). The beta coefficient ($\beta = 0.684$, $t = 16.18$, $p < 0.05$) confirms that for every unit increase in structured digital tool engagement, a student's cognitive score on the microplastics test increases by 0.724 points. Therefore, the null hypothesis (H_{02}) is rejected, confirming that digital tool engagement is a significant positive predictor of actual environmental learning outcomes.

Hypothesis 3 (H_{03}) : Perceived challenges to digital access do not exert a statistically significant negative influence on the post-test Microplastics Knowledge Achievement Test (MKAT) scores of NCE 2 Biology students. To determine if structural and financial constraints (such as poor connectivity and high data costs) actively hindered academic achievement during the digital intervention, a Simple Linear Regression Analysis was conducted. The

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Independent Variable was the composite Challenges to Digital Access index, and the Dependent Variable was the post-test MKAT Score Matrix. The results is presented in Table 9

Table 9: Linear Regression Model Summary on the Influence of Digital Barriers

Independent Predictor	Multiple (R)	R-Square (R^2)	Adjusted (R^2)	Standard Error	F-Value	Significance (p)
Perceived Digital Challenges	0.412	0.170	0.167	0.614	60.94	< 0.05

Table 10: Regression Coefficients of the Digital Barriers Predictor Model

Model Elements	Unstandardized Beta (β)	Std. Error	Standardized Beta (β)	Calculated t-value	Significance (p)
Constant (Intercept)	45.120	0.245	—	184.16	< 0.05
Perceived Digital Challenges	-0.385	0.049	-0.412	-7.81	< 0.05

The regression metrics compiled in Table 9 and Table 10 reveal a statistically meaningful negative relationship between digital access barriers and academic performance. The correlation coefficient ($R = 0.412$) establishes a moderate inverse linear relationship. The coefficient of determination ($R^2 = 0.170$) shows that 17.0% of the total variance in students' final post-test microplastic knowledge scores is directly explained by the severity of the technical and financial challenges they encountered. The overall model fit is highly significant ($F = 60.94$, $p < 0.05$). Looking at the individual coefficients, the unstandardized beta ($\beta = -0.385$) and the calculated t-value ($t = -7.81$, $p < 0.05$) confirm a significant negative direction. This indicates that for every 1-point increase in the severity of digital challenges (such as loss of power or dropped connections), a student's final score on the microplastics test dropped by an average of 0.385 points. Consequently, the null hypothesis (H_{03}) is rejected, and the alternative hypothesis (H_{a3}) is accepted. This empirical finding proves that external systemic and economic infrastructure barriers do more than just frustrate students; they exert a statistically significant negative drain on actual environmental education learning outcomes.

Discussion of Findings

The discussion synthesizes the empirical evidence gathered from the Microplastics Knowledge Achievement Test (MKAT) and the Digital Intervention Engagement Questionnaire (DIEQ), contextualizing these findings within the broader landscape of environmental health education through a comparison with both corroborative and contradictory empirical literature.

Evaluation of Baseline Cognitive Knowledge Deficits

The pre-test results revealed a profound deficiency in foundational knowledge regarding microplastics among the NCE 2 Biology students ($X = 19.20$). This baseline deficit directly mirrors recent global trends in public environmental health

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literacy. For instance, this finding is strongly supported by Akpan et al. (2021) in a study on environmental health education in Nigeria, which reported that before receiving targeted instruction, higher education cohorts displayed very weak awareness regarding non-biodegradable synthetic particles and their pathways into local aquatic ecosystems. Similarly, the widespread inability of students to identify products containing microbeads or explain how fragmentation enters the biological food chain highlights a major gap in conventional science education curricula, corroborating the findings of Alabi and Azeez (2023), who noted that standard pre-service teacher programs rarely incorporate emerging chemical and plastic pollution topics.

Conversely, this baseline deficit contradicts the findings of a European study by Weber and Schulz (2022) on microplastic awareness techniques, which observed high baseline awareness among undergraduate biology students. Weber and Schulz attributed this pre-existing knowledge to pervasive environmental campaigns and high-density regional public discourse. The sharp divergence between their findings and the current study emphasizes that baseline environmental literacy is heavily dependent on localized geographic factors, policy priorities, and the intensity of regional public environmental advocacy. Without active and targeted educational interventions, even science-oriented undergraduate students in developing academic environments remain largely isolated from contemporary ecological discourse.

Effectiveness of the Structured Digital Tool Intervention

Exposure to the six-week curated digital content program resulted in a statistically significant surge in cognitive knowledge, with post-test scores jumping by a mean gain of +20.15 points ($X = 39.35$, $p < 0.001$). This substantial outcome confirms that mobile learning approaches can effectively drive environmental education. The significant shift strongly validates the findings of an experimental study on mobile app-based educational interventions by Ibrahim and Bello (2024), which demonstrated that structured, application-driven mobile learning packages yielded immediate and lasting cognitive improvements regarding the health effects of microplastics among tertiary students.

However, this dramatic success runs contrary to the classical experiential learning paradigms advanced by Olayinka (2020), who evaluated microplastic education strategies. Olayinka's empirical data showed that purely digital or virtual interventions were significantly less effective at fostering long-term cognitive retention of environmental topics when compared to face-to-face classroom lectures combined with physical laboratory experiments. This discrepancy suggests that while a digital intervention offers immediate advantages in content distribution and visual demonstration, its long-term efficacy may depend heavily on structural variables such as the duration of exposure and the technical nature of the content delivered.

Media Formats and the Predictive Value of Engagement

A central finding from the linear regression model is that digital engagement trends strongly predict final cognitive test scores ($R^2 = 0.468$, $p < 0.05$). This mathematical model indicates that 46.8% of the positive change in a student's final test score is directly determined by how actively they interact with the digital tools provided. Descriptively, students identified Instagram Reels/Stories (78.3% usage, $X = 4.12$) and TikTok Short Videos (72.7% usage, $X = 3.98$) as the most effective mediums for understanding complex environmental problems. This preference highlights a major shift in how modern student demographics consume information, aligning perfectly with a systematic review on digital tools for fostering sustainability

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awareness by Santos and Silva (2023), which noted that modern student audiences engage far better with brief, high-impact video graphics than with static, text-heavy institutional websites. Interestingly, this heavy preference for short-form social media entertainment platforms is sharply contested by the findings of Chen and Wong (2024) in their review on digital technologies in environmental education. Chen and Wong's work revealed that while social media videos maximize user attention and initial engagement, they significantly underperform when compared to structured academic portals like the UNEP Microplastics Portal (which scored low at 31.0% usage in this study). They argued that short-form videos often lead to superficial understanding and cognitive fragmentation, failing to deliver the rigorous data necessary for scientific education. The contrast between the current study and Chen and Wong's findings implies a trade-off in digital environmental education: social media platforms excel at generating wide engagement and building broad baseline awareness, but specialized scientific portals remain necessary to cultivate deep, analytical scientific competence.

Systemic Constraints and Infrastructure Barriers

The rejection of the third null hypothesis H_{03} provides critical proof that technical and economic barriers directly degrade academic performance. The model shows that 17% of the variation in final test scores was tied to how badly a student was impacted by infrastructure failures. This finding aligns with Okafor and Chinedu (2022), who argued that digital literacy programs in regional institutions often suffer from "frustrated learning curves," where eager students underperform simply due to intermittent data access. Crucially, this finding contradicts the idealized assumptions of Ibrahim and Bello (2024), who suggested that mobile micro-learning platforms are completely immune to environmental context due to their asynchronous nature. The data shows that asynchronous flexibility cannot overcome severe infrastructure deficits; if a pre-service teacher cannot afford data or cannot charge their phone due to power outages, their cognitive engagement drops, directly lowering their final test scores. Despite the clear cognitive improvements achieved, the study revealed that systemic infrastructure deficits present severe roadblocks to digital education models. Poor internet connectivity (81.0%, Severity = 4.32) and the high cost of mobile data (77.0%, Severity = 4.18) stood out as the dominant challenges reported by the participants. This reality aligns perfectly with Okafor and Chinedu (2022), who cautioned that while digital learning holds great potential in developing nations, its real-world implementation is often limited by external economic factors, technological access gaps, and regional infrastructure issues.

Importantly, internal issues like low digital literacy (18.0%) or language barriers (21.0%) ranked among the lowest concerns. This shows that the NCE 2 Biology students have the necessary technical skills and desire to learn online, but are bottlenecked by high data costs and weak internet networks. This directly disproves the claims made by Amadi (2021), who stated that the primary barrier to digital education in sub-Saharan colleges of education was a lack of user digital competency and student resistance to digital academic platforms. The current empirical evidence proves that students are ready and capable of navigating digital education, shifting the blame entirely away from student competence and onto institutional and national infrastructure deficits.

Conclusion(s)

Based on the empirical findings of this study, it is concluded that structured digital interventions are highly effective and potent tools for improving contemporary environmental health literacy among pre-service science teachers. While traditional

science education delivery models often leave students insulated from emerging ecological crises like microplastic pollution, researcher-curated digital media effectively bridged this cognitive gap. Furthermore, modern undergraduate students possess the necessary digital navigation skills and willingness to engage with academic content online, especially when delivered through interactive, short-form video streaming formats. However, the educational potential of these digital strategies remains severely bottlenecked by external infrastructure deficits and economic constraints rather than a lack of student capacity.

Recommendations

In light of the findings and conclusions established in this study, the following policy and administrative recommendations are made:

1. Curriculum Modernization: The Academic Board of the Federal College of Education, Okene, through the School of Sciences, should officially integrate emerging global environmental health crises such as microplastic accumulation and chemical eco-toxicity into the formal NCE Biology instructional curriculum.
2. Institutional Infrastructure Investment: The college management must expand campus-wide ICT infrastructure by providing high-speed, institutional Wi-Fi zones across lecture halls and science laboratories. This will directly mitigate the severe internet connectivity barriers highlighted by 81% of the participants.
3. Subsidized Digital Access: Academic institutions should collaborate with major regional telecommunications providers to arrange zero-rated or subsidized mobile data tokens specifically tailored for accessing vetted educational portals and mobile learning applications.
4. Pedagogical Shift to Micro-Learning: Science educators should actively pivot toward multi-modal micro-learning techniques. Lecturers should design brief, high-impact video graphics and infographics to complement traditional laboratory exercises, leveraging students' heavy usage of visual social platforms for formal academic achievement.

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References

Akpan, U. O., Ekong, E. E., & Udoh, N. J. (2021). Assessing environmental health literacy among science education undergraduates in Nigerian tertiary institutions. *Journal of African Environmental Education, 14*(2), 112–126.

Alabi, T. A. (2019). Plastic additives and chemical leaching: Assessing safety thresholds in containerized consumer beverages. *West African Journal of Applied Chemistry, 27*(1), 14–28.

Alabi, T. A., & Azeez, O. R. (2023). Integrating contemporary ecological hazards into pre-service teacher curricula: Gaps and prospects. *Nigerian Journal of Science and Science Education, 19*(1), 45–59.

Albe, M. I., Chukwu, P. O., & Nelson, G. (2024). Electronic media learning technologies for environmental education delivery in Nigerian tertiary institutions: Institutional readiness and infrastructural challenges. *Journal of Educational Technology Systems,* 52(3), 241–258.

Amadi, C. E. (2021). Overcoming digital resistance: An evaluation of user competence among pre-service teachers in sub-Saharan colleges of education. *African Journal of Educational Technology, 8*(3), 201–215.

Andrady, A. L. (2017). The plastic in our oceans: Fragmentation mechanisms and the production of marine microplastics. *Marine Pollution Bulletin, 115*(1-2), 1–12.

Ardoin, N. M., Bowers, A. W., & Gaillard, E. (2020). Environmental education outcomes for conservation: A systematic review. Studies in Educational Evaluation, 66, Article 100895.

Babayemi, J. O., Ogundiran, M. B., & Weber, R. (2019). Initial assessment of plastic waste flows, management scenarios, and microplastic emergence avenues in Nigeria. *Environmental Science and Pollution Research, 26*(14), 14321–14337.

Boucher, J., & Friot, D. (2017). Primary microplastics in the oceans: A global evaluation of sources. IUCN.

Chen, L., & Wong, K. F. (2024). Digital technologies in environmental education: Rigorous academic portals versus social media video dissemination. *International Journal of Sustainability in Higher Education, 25*(2), 310–328.

Cochran, W. G. (1977). Sampling techniques (3rd ed.). John Wiley & Sons.

Cole, M., Lindeque, P., Halsband, C., & Galloway, T. S. (2011). Microplastics as contaminants in the marine environment: A review. *Marine Pollution Bulletin, 62*(12), 2588–2597. doi.org.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly, 13*(3), 319–340.

Deng, Y., Zhang, Y., & Lemos, B. (2020). Tissue accumulation, tissue distribution, and health risks of microplastic ingestion: Why public awareness lags behind toxicology data. *Journal of Hazardous Materials,* 391, Article 122249.

Deng, X., & Yu, Z. (2023). An extended hedonic motivation adoption model of TikTok in higher education. *Education and Information Technologies, 28*(9), 12153–12177.

Eddine, N., & Mahmoudi, M. (2025). The impact of short educational videos on tertiary students' environmental awareness, attitudes, and behavioural intentions. *Journal of Environmental Multimedia Education, 11*(1), 14–29.

Geyer, R., Jambeck, J. R., & Law, K. L. (2017). Production, use, and fate of all plastics ever made. Science Advances, 3(7), e1700782.

Hajj-Hassan, M., Chaker, R., & Cederqvist, A. M. (2024). Environmental education: A systematic review on the use of digital tools for fostering sustainability awareness. *Sustainability*, 16(9), Article 3733.

Ibrahim, M. K., & Bello, A. S. (2024). Mobile app-based educational interventions for environmental health literacy: An experimental approach. *Journal of Digital Learning in Teacher Education, 40*(1), 74–89.

Kollmuss, A., & Agyeman, J. (2002). Mind the gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? *Environmental Education Research, 8*(3), 239–260.

Ogunola, O. S., Onada, I. O., & Falaye, A. E. (2022). Mitigation pathways for plastic pollution in Nigeria: Assessing baseline awareness gaps among higher education youth demographics. *Environmental Challenges,* 7, Article 100495.

Okafor, J. N., & Chinedu, S. A. (2022). Infrastructural roadblocks to digital academic platforms in regional higher education institutions. *West African Journal of Open and Flexible Learning*, *10*(2), 88–105.

Olayinka, S. B. (2020). Experiential vs. virtual learning: Evaluation of microplastic education strategies in undergraduate laboratories. *Journal of Research in Science Teaching, 57*(8), 1204–1222.

Omoyajowo, K. O. (2021). The political economy of polymers: Driving factors of synthetic material demand and flourishing plastic production networks in global south market structures. *Journal of Cleaner Production,* 294, Article 126210.

PlasticsEurope. (2023). Plastics – the facts 2023: An analysis of European plastics production, demand and waste data. PlasticsEurope Market Research Group.

Prata, J. C., Silva, A. L., da Costa, J. P., Mouneyrac, C., Walker, T. R., Duarte, A. C., & Rocha-Santos, T. (2020). Solutions and actions to mitigate microplastics pollution globally: The critical interface of science communication and civic awareness. *Science of The Total Environment,* 745, Article 141126.

Santos, M. R., & Silva, A. P. (2023). Digital tools for fostering sustainability awareness among contemporary student demographics: A systematic review. *Environmental Education Research,* 29(4), 512–531.

Severo, E. A., de Guimarães, J. C. F., & Dorion, E. C. H. (2019). Social media and pro-environmental behavior: Analysis of university students in Brazil. *Journal of Cleaner Production, 233,* 1247–1256.

Taber, K. S. (2018). The use of Cronbach's alpha when developing and reporting research instruments in science education. *Research in Science Education, 48*(6), 1273–1296.

Thompson, R. C., Olsen, Y., Mitchell, R. P., Davis, A., Rowland, S. J., John, A. W., McGonigle, D., & Russell, A. E. (2004). Lost at sea: Where is all the plastic? *Science,* 304(5672), 838–838.

Weber, F., & Schulz, H. (2022). Microplastic awareness techniques and baseline ecological literacy among European biology undergraduates. *European Journal of Science Education*, 44(3), 341–356.

World Wide Fund for Nature. (2019). No plastic in nature: Assessing plastic ingestion from nature to people. WWF International Report.

Wright, S. L., & Kelly, F. J. (2017). Plastic and human health: A microplastic perspective. *Environmental Science & Technology, 51*(12), 6634–6647.