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Virtual Reality's Impact on Public Engagement with Climate Change Scenarios in Nigeria

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ABSTRACT

Climate change is regarded by scholars as one of the most consequential environmental challenges of the twenty-first century, yet public awareness and behavioral engagement are kept critically low across sub-Saharan Africa, including Nigeria. The impact of Virtual Reality (VR) technology on public engagement with climate change scenarios in Jalingo Education Zone, Taraba State, Nigeria, was investigated in this study through a descriptive survey design. Construal Level Theory, Embodied Simulation Theory, the Extended Elaboration Likelihood Model, and Social Cognitive Theory were drawn upon to examine how climate literacy, empathic identification with climate-affected communities, and pro-environmental behavioral intentions are influenced by immersive VR experiences. Data were collected by a structured questionnaire administered to a sample of 320 respondents drawn from educational institutions, governmental agencies, and community organizations in Jalingo Education Zone, and were analyzed using descriptive statistics and inferential techniques including mean scores, standard deviation, and Analysis of Variance (ANOVA). Climate change salience is significantly elevated by VR, empathy with vulnerable communities is enhanced, and stronger pro-environmental behavioral intentions are generated compared to conventional communication modalities, the findings indicate. However, the scalability of VR interventions in the study area is constrained by critical barriers, including infrastructural deficits, prohibitive hardware costs, content localization inadequacies, and digital literacy gaps. It is concluded that while substantial promise as an instrument of climate change public engagement in Nigeria is held by VR, coordinated policy action, targeted investment in digital infrastructure, locally contextualized content development, and integration into science education curricula at secondary and tertiary levels are required for its effective deployment.

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INTRODUCTION

Climate change is identified by the Intergovernmental Panel on Climate Change (IPCC, 2021) as an existential global threat requiring unprecedented societal transformation. In Nigeria, the world's most populous Black nation and Africa's largest economy, intensified flooding across the Niger Delta, accelerating desertification in the Lake Chad Basin, disrupted agricultural calendars, and sea-level rise threatening coastal communities are manifested as consequences of climate change (Oguge et al., 2021; Onyeneke et al., 2022). Despite the severity and immediacy of these impacts, low levels of climate literacy, inadequate risk perception, and minimal behavioral engagement are consistently revealed by surveys of the Nigerian public (Nwobodo & Chukwueke, 2023).

Jalingo Education Zone, the capital of Taraba State, situated at the confluence of

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ecological transition zones, is rendered particularly vulnerable to climate variability, with erratic rainfall, soil erosion, and declining agricultural productivity experienced by communities as a result of anthropogenic climate forcing (Federal Ministry of Environment, 2021).

Limited efficacy in translating abstract climate projections into personally relevant, action-motivating narratives has been demonstrated by traditional climate communication strategies, including print media campaigns, radio broadcasts, and conventional classroom instruction (Corner et al., 2020). The challenge of psychological distance, wherein climate change is perceived as spatially, temporally, and socially remote from immediate circumstances, is particularly pronounced where immediate livelihood pressures compete for cognitive and emotional resources (Trope & Liberman, 2010). Within Jalingo, where significant proportions of the population engage in subsistence agriculture and informal economic activities, the salience of distant climate projections may be further attenuated by pressing daily concerns.

Virtual Reality (VR), a computer-generated three-dimensional environment that immerses users through head-mounted displays (HMDs) or comparable interfaces, has attracted considerable scholarly attention as a medium for experiential learning and behaviour change (Makransky & Lilleholt, 2022). Inundated urban environments, drought-ravaged farmlands, and bleached coral ecosystems can be simulated by VR, which positions it as a uniquely powerful instrument for collapsing psychological distance and fostering empathic engagement (Markowitz et al., 2021). Significantly stronger pro-environmental intentions than equivalent text-based or video-based communications were shown by Ahn et al. (2020) to be generated by embodied VR experiences. Yet VR for climate change communication within Jalingo Education Zone and analogous Nigerian contexts remains a nascent and systematically underdeveloped area of empirical investigation.

Didactic and textbook-centered pedagogies, inadequate for fostering the affective engagement and behavioral motivation necessary for meaningful climate action, have historically been relied upon by science education in Nigeria (Adeleke & Ogunlade, 2022). A compelling case for investigating VR's role as an instrument of science-informed climate communication is created by the growing availability of mobile-compatible VR platforms within Nigeria's digital economy, coupled with the acute climate vulnerability of Taraba State communities. The impact of VR technology on public engagement with climate change scenarios in Jalingo Education Zone is therefore empirically investigated in this study, with implications drawn for science education policy and practice.

STATEMENT OF THE PROBLEM

A demonstrable gap between the severity of climate change impacts and the level of public awareness, risk perception, and behavioral engagement exists among Nigerian communities, notwithstanding the nation's acute and escalating climate vulnerability. This gap has proven insufficiently bridged by conventional science communication approaches, and a critical absence of empirically grounded, context-specific research on innovative immersive technologies such as VR for climate engagement is found within Nigerian metropolitan contexts (Usman et al., 2023). Infrastructural deficits, limited digital literacy, and a paucity of locally contextualized VR content compound the problem of inadequate climate change public engagement in Jalingo Education Zone, impeding the deployment and uptake of evidence-based immersive communication interventions.

Purpose of the Study

The impact of Virtual Reality (VR) technology on public engagement with climate change scenarios among residents of Jalingo Education Zone, Taraba State, Nigeria, is empirically investigated as the primary purpose of this study. Specifically, the extent to which climate literacy is enhanced by VR climate simulations is assessed; how empathic identification with climate-affected communities is fostered by VR-mediated climate communication is examined; the

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influence of VR climate experiences on pro-environmental behavioral intentions is determined; and the structural and contextual barriers that inhibit effective VR deployment are identified. Contextually grounded empirical evidence that can inform science education policy, curricular innovation, and technology integration strategies is sought to be generated through these aims.

Research Questions

The study was guided by the following questions:

1. To what extent is climate literacy among residents of Jalingo Education Zone influenced by exposure to Virtual Reality climate change scenarios?
2. How is empathic identification with climate-affected communities affected by VR-mediated climate communication?
3. What impact do VR climate experiences have on pro-environmental behavioral intentions among residents of Jalingo Education Zone?
4. What structural and contextual barriers inhibit effective VR deployment for climate change engagement in Jalingo Education Zone?

METHODOLOGY

A descriptive survey research design was adopted in this study to systematically investigate the impact of VR technology on public engagement with climate change scenarios in Jalingo Education Zone, the capital city of Taraba State, Nigeria. Residents of Jalingo Education Zone aged 18 years and above, including tertiary students, public servants, teachers, farmers, and market traders, comprised the target population, estimated at approximately 185,000 persons based on 2023 National Population Commission projections. A sample of 320 respondents was selected through stratified random sampling, with strata defined by occupational category and random selection applied within each stratum to ensure representativeness.

A researcher-developed, structured questionnaire titled the VR Climate Engagement Assessment Scale (VR-CEAS) served as the primary data collection instrument, comprising 48 items organized across four subscales: Climate Literacy Enhancement, Empathic Engagement, Pro-environmental Behavioral Intentions, and Barriers to VR Adoption (12 items each). A five-point Likert scale ranging from Strongly Agree (5) to Strongly Disagree (1) was used to rate all items. Content validity was established through expert review by three specialists at Taraba State University, while internal consistency reliability was confirmed through a pilot study yielding a Cronbach's alpha of 0.87.

In-person VR demonstration sessions using Meta Quest 2 headsets loaded with localized Nigerian climate content were combined with immediate post-experience questionnaire administration in the data collection procedure. Frequency counts, percentages, means, and standard deviations were computed to summarize respondent characteristics, and one-way ANOVA and independent samples t-tests were employed to examine differences in engagement outcomes by demographic subgroup, with significance set at $p < .05$.

RESULTS

Socio-Demographic Characteristics of Respondents

Out of the 320 questionnaires administered, 308 were returned fully completed (response rate: 96.3%). Table 1 presents respondents' socio-demographic characteristics.

Table 1: Socio-Demographic Characteristics of Respondents (N = 308)

Variable	N	%
Gender: Male	174	56.5%
Gender: Female	134	43.5%
Occupation: Students	107	34.7%
Occupation: Civil Servants	75	24.4%
Occupation: Teachers	57	18.5%
Occupation: Traders	42	13.6%

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Variable	N	%
Occupation: Farmers	27	8.8%
Smartphone use (prior)	207	67.2%
Prior VR exposure	38	12.3%

Climate Literacy Enhancement (RQ1)

A post-VR mean score of 4.21 (SD = 0.63) on the 5-point scale was revealed by analysis of the Climate Literacy Enhancement subscale, indicating high agreement that climate literacy was enhanced by VR exposure. The specific mechanisms through which climate change affects Taraba State communities were reported as better understood by 83.4% of respondents after the VR experience.

The item rated highest was that the VR simulation made climate change consequences feel real and personally relevant (M = 4.38, SD = 0.58), while the lowest-rated item concerned explaining climate processes to others (M = 3.97, SD = 0.74), suggesting that affective salience was generated more effectively by VR than transmissible declarative knowledge. A statistically significant difference in literacy enhancement scores by educational attainment was indicated by one-way ANOVA ($F(3, 304) = 6.84$, $p = .001$), with significantly higher gains reported by tertiary-educated respondents than those with only primary or no formal education.

Table 2: Climate Literacy Enhancement Subscale Results (RQ1)

Item / Measure	Mean	SD	Key Finding
Overall Subscale Score	4.21	0.63	High enhancement; 83.4% agreed
Highest item: feels real and relevant	4.38	0.58	Strong affective salience
Lowest item: can explain to others	3.97	0.74	Weaker declarative transfer
ANOVA by education level	F=6.84	p=.001	Tertiary group gained most

Empathic Engagement with Climate-Affected Communities (RQ2)

Table 3 summarizes empathic engagement subscale results across respondent categories in Jalingo Education Zone.

Table 3: Empathic Engagement with Climate-Affected Communities (RQ2)

Item / Measure	Mean	SD	Key Finding
Overall Subscale Score	4.09	0.71	79.2% reported emotional connection
Reconsidered human cost of inaction	—	—	76.6% agreed after VR
First-time VR users	4.13	0.68	Novelty effect non-significant
Prior VR users	3.98	0.79	
Farmers (highest empathy group)	4.31	0.57	Direct occupational exposure

Pro-Environmental Behavioral Intentions (RQ3)

A mean of 3.87 (SD = 0.84) was yielded by pro-environmental behavioral intention scores, reflecting moderate-to-high stated intention to adopt pro-environmental behaviors following VR exposure. The intention to reduce household energy consumption was most strongly endorsed (M = 4.02, SD = 0.79), while participation in community climate advocacy received the lowest endorsement (M = 3.61, SD = 0.91), indicating that individually enacted conservation behaviors were

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intended more frequently than collective or civic engagement behaviors. No statistically significant gender differences in behavioral intention scores were revealed by ANOVA ($F(1, 306) = 2.11$, $p = .148$), though significantly stronger behavioral intentions were reported by respondents aged 18–30 than those aged 46–56 ($F(3, 304) = 4.72$, $p = .003$).

Table 4: Pro-Environmental Behavioral Intentions (RQ3)

Item / Measure	Mean	SD	Key Finding
Overall Subscale Score	3.87	0.84	Moderate-to-high intentions
Highest: reduce energy consumption	4.02	0.79	Individual behaviors favored
Lowest: community climate advocacy	3.61	0.91	Collective action least endorsed
Gender difference (ANOVA)	F=2.11	p=.148	Non-significant
Age: 18-30 vs 46-56 yrs	F=4.72	p=.003	Younger group stronger

Barriers to VR Adoption (RQ4)

An overall mean of 4.14 (SD = 0.69) was yielded by the Barriers subscale, confirming that substantial barriers to VR adoption were perceived by respondents in Jalingo Education Zone. Unreliable electricity supply was the most highly endorsed barrier (M = 4.52, SD = 0.51), followed by the cost of VR equipment (M = 4.41, SD = 0.57), the absence of Taraba State-specific VR content (M = 4.28, SD = 0.63), and insufficient teacher training (M = 4.17, SD = 0.71). Technology anxiety was endorsed by 42.5% of respondents, indicating significant but not dominant resistance.

Table 5: Perceived Barriers to VR Adoption for Climate Engagement (RQ4)

Barrier Item	Mean	SD	Significance
Overall Barriers Subscale Score	4.14	0.69	Substantial across categories
Unreliable electricity supply	4.52	0.51	Most critical barrier
Prohibitive VR hardware cost	4.41	0.57	Second most critical
Absence of localized VR content	4.28	0.63	Content gap identified
Insufficient teacher training	4.17	0.71	Capacity need
Technology anxiety	—	—	42.5% of respondents

DISCUSSION OF FINDINGS

Virtual Reality and Climate Literacy Enhancement

The finding that climate literacy among Jalingo respondents was significantly enhanced by VR is consistent with a robust body of international evidence. Significantly higher recall of climate information and stronger expressed concern, compared to non-immersive equivalents, were shown by Markowitz et al. (2021) to be produced by immersive VR field trips, corroborating the present finding. As explicated by Construal Level Theory (Trope & Liberman, 2010), the psychological distance of climate change is reduced by immersive simulation, enabling users to encode information within personally relevant, concrete schemas rather than abstract representations.

The greater literacy gains reported by tertiary-educated respondents align with Adedoyin and Soyemi (2022), who observed that deeper

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processing of VR climate content was facilitated by pre-existing conceptual frameworks for environmental science. Structured post-VR reflection activities such as guided discussion or peer teaching are suggested by the relatively lower scores on transmissible declarative knowledge items, an approach advocated by Makransky and Lilleholt (2022) as a key moderator of VR learning effectiveness.

Virtual Reality and Empathic Engagement

Nigerian-specific corroboration of findings previously established mainly in Western contexts is provided by the robust empathic responses generated among Jalingo respondents, over three-quarters of whom expressed strong emotional connection to depicted communities. Significantly stronger empathy and conservation intentions than observer-perspective media were demonstrated by Ahn et al. (2020) to be generated by embodied perspective-taking through VR, the precise mechanism operationalized in the present study's demonstrations.

The highest empathy scores reported by farmers accord with Yusuf and Adebayo's (2024) Kaduna State study, wherein heightened empathic resonance with VR-depicted climate futures was primed by direct occupational exposure to agricultural disruption. The near-absence of a novelty effect among prior VR users suggests that the empathic mechanism is substantive rather than artifactual, consistent with Embodied Simulation Theory's postulate that empathy arises from somatic neural simulation rather than perceptual novelty alone (Gallese, 2021). That VR can bridge intra-national as well as international experiential divides is further established by Balogun et al.'s (2023) cross-regional empathy findings.

VR and Pro-Environmental Behavioral Intentions

Makransky and Lilleholt's (2022) meta-analytic finding of a moderate pooled effect size (r = 0.29) for VR on behavioral intentions is aligned with by the moderate-to-high intentions reported in the present study, while a pattern observed by Nwobodo and Chukwueke (2023) among Enugu State students is replicated by the attenuation of collective relative to individual conservation intentions. Heightened openness to technology-mediated behaviour changes among Nigerian youth, as found by Adeleke and Ogunlade (2022), is consistent with the strong intentions reported by younger respondents, and the social cognitive mechanism proposed by Zimmerman and Schunk (2023) suggests that modelled behaviors in simulated environments more readily influence individuals with greater cognitive flexibility

. Some international studies suggesting stronger pro-environmental intentions among women (Soliman et al., 2020) are departed from by the non-significant gender difference observed here, potentially reflecting context-specific social dynamics within Jalingo. Supplementation with community-level engagement mechanisms, a gap also identified by Soga et al. (2021), may be required to translate individual affect into collective mobilization, as suggested by the weaker endorsement of collective action intentions.

Barriers to Virtual Reality Adoption

The existing barrier typology documented in the literature is confirmed and extended by the high barrier scores recorded in this study. Disproportionate power access deficits faced by rural and peri-urban northern settlements, as analyzed by Oyedepo (2023), are consistent with the primacy of electricity supply as a barrier in Jalingo. Inadequate power and connectivity infrastructure for VR deployment was found by Eze and Obiechina (2022) to characterize fewer than 12% of Southeast Nigerian secondary schools, a finding that likely generalizes to Jalingo. Usman et al.'s (2023) qualitative findings, wherein cultural disconnection from internationally produced VR climate materials was consistently reported by participants across four geopolitical zones, are substantiated by the strong endorsement of content localization as a barrier by nearly 85% of respondents.

A non-trivial barrier, particularly for populations with limited prior technology exposure, is represented by the finding that over

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40% of respondents are affected by technology anxiety. Orientation protocols, session duration limits, and careful hardware selection are suggested by Stanney et al.'s (2020) analysis of cybersickness determinants as means by which technology anxiety can be substantially mitigated.

IMPLICATIONS FOR SCIENCE EDUCATION

Significant implications for science education policy and practice at the secondary and tertiary levels in Jalingo Education Zone, and by extension across Taraba State and Nigeria, are carried by the present findings. First, strong empirical grounds for the integration of immersive technology into secondary school environmental science and geography curricula are provided by the demonstrated effectiveness of VR in enhancing climate literacy and empathic engagement. The National Curriculum for Senior Secondary Schools should be revised by NERDC (2020) to incorporate VR-based learning experiences as a pedagogically valid approach to climate change education; without such curricular legitimation, idiosyncratic and unsustainable adoption is likely to persist.

Second, systematic VR literacy integration into pre-service and in-service science teacher education programmes at Taraba State University and analogous institutions is underscored as imperative by the study. High receptivity to VR climate content among educators, combined with successful VR pedagogy integration demonstrated by Isiaka et al. (2023) at the University of Abuja, suggests that teacher training initiatives creating a pipeline of VR-competent educators can well be led by faculties of science education.

Third, enabling conditions for VR adoption are implicated as the responsibility of institutional stakeholders including TETFund, UBEC, and the Taraba State Ministry of Education by the identification of significant infrastructure, cost, and localization barriers. Concrete policy responses that would substantially increase VR's practical applicability include targeted infrastructure grants, equipment-sharing schemes, and commissions for locally produced climate VR content.

Fourth, a methodological opportunity for Nigerian science education research is highlighted by the study. Novel experimental paradigms for investigating climate risk perception and behaviour change in ecologically valid contexts are afforded by VR, a significant advance over conventional survey-based approaches. Both national education improvement and the international knowledge base on VR-mediated science education would be contributed to by VR research laboratories established within Taraba State and North-East universities.

CONCLUSION

Substantial and evidence-grounded potential as an instrument for enhancing public engagement with climate change scenarios in Jalingo Education Zone has been empirically established for Virtual Reality technology by this study. Through a descriptive survey administered to 308 residents across diverse occupational strata, it was demonstrated that climate literacy is significantly elevated, robust empathic responses to climate-affected communities are generated, and moderate-to-high pro-environmental behavioral intentions are stimulated by VR climate experiences.

The mechanisms of psychological distance reduction, embodied empathy, dual-route persuasion, and self-efficacy enhancement posited respectively by Construal Level Theory, Embodied Simulation Theory, the Extended Elaboration Likelihood Model, and Social Cognitive Theory are theoretically coherent with these findings, which are empirically consistent with international and Nigeria-specific evidence. Simultaneously, the practical scalability and equitable accessibility of VR climate engagement initiatives are confirmed by this study to be constrained by significant structural barriers, including chronic electricity deficits, prohibitive hardware costs, the paucity of culturally contextualized VR content, and substantial technology anxiety among a notable minority.

VR's potential is not negated by these barriers, but the coordinated policy, institutional, and technological investments necessary to translate demonstrated efficacy into broad-scale

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impact are delineated by them. A genuinely transformative tool for Nigerian climate change education and public engagement, capable of bridging gaps that conventional approaches have been unable to close, is represented by VR when appropriately contextualized and systematically supported. Sustained commitment from educators, researchers, policymakers, and technology developers across Nigeria's education and innovation ecosystem is demanded for this potential to be realised.

RECOMMENDATIONS

Based on the empirical findings, the following recommendations are advanced:

1. The National Curriculum for Senior Secondary Schools should be revised by NERDC and the Federal Ministry of Education to formally incorporate VR and immersive technologies into environmental science, geography, and civic education curricula, accompanied by teacher competency standards.
2. VR technology literacy modules should be developed and institutionalized within pre-service science teacher education programmes by Taraba State University's Faculty of Science Education and cognate institutions across Nigeria.
3. Dedicated grant windows for VR infrastructure procurement and the commissioning of contextually localized VR climate content should be established by TETFund and UBEC.
4. WebXR-compatible, low-bandwidth, offline-capable climate VR content localized for Nigerian contexts should be prioritized for development by VR developers and technology enterprises, incorporating participatory design with community members and climate scientists.
5. Rigorous longitudinal studies assessing the durability of VR-induced climate attitude and behaviour change should be designed and executed by Nigerian science education researchers to build the localized evidence base for sustained policy investment.

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