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Article

Effectiveness of the NonVisual Desktop Access (NVDA) Screen Reader in Enhancing Climate Change Education among Learners with Visual Impairment in Selected Inclusive Secondary Schools in Kogi State, Nigeria

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Abstract: This study evaluated the effectiveness of the NonVisual Desktop Access (NVDA) screen reader in enhancing climate change education among visually impaired students in selected inclusive secondary schools in Kogi State, Nigeria. Specifically, the study examined the effect of the NVDA screen reader on students' academic performance, engagement during instruction, and learning outcomes in selected climate change concepts. A quantitative quasi-experimental pre-test–post-test non-equivalent control group design was adopted. The study involved 83 visually impaired senior secondary school students drawn from three inclusive secondary schools. The participants were assigned to an experimental group (n = 41), which received instruction using the NVDA screen reader, and a control group (n = 42), which was taught using conventional oral instructional methods. Data were collected using the researcher-developed Climate Change Achievement Test (CCAT) and Student Engagement Scale (SES), with reliability coefficients of 0.82 and 0.86, respectively. Descriptive statistics were used to answer the research questions, while Analysis of Covariance (ANCOVA) was used to test the hypotheses at the 0.05 level of significance. The findings revealed that students in the experimental group achieved higher academic performance (post-test mean = 28.17; mean gain = 6.61) than those in the control group (post-test mean = 24.10; mean gain = 2.67). The ANCOVA result showed a significant difference in academic performance, $F(1, 80) = 10.87$, $p = 0.0016$. Similarly, students taught using the NVDA screen reader demonstrated higher engagement (post-test mean = 42.34) than those taught using conventional instruction (post-test mean = 36.10), with a significant difference observed, $F(1, 80) = 26.83$, $p < 0.0001$. The study concluded that the NVDA screen reader significantly improves the academic performance, engagement, and learning outcomes of visually impaired students in climate change education. The study recommended the integration of NVDA into inclusive science education, regular teacher training, and the provision of accessible digital learning resources in secondary schools.

Keywords: NVDA screen reader, climate change education, visual impairment, academic performance, learner engagement, inclusive education

Introduction

Climate change remains a critical global concern, particularly for developing countries such as Nigeria, where environmental degradation, flooding, desertification, and erratic weather patterns continue to disrupt livelihoods, education, and health systems. In response, Olatunde-Aiyedun et al. stated that climate change education (CCE) has gained global attention as a vital tool for equipping learners with the knowledge, values, and competencies needed to understand environmental challenges and take informed climate action. Recent studies further emphasize that climate change education enhances environmental literacy, promotes sustainable behaviour, and strengthens resilience among young people. However, access to CCE remains uneven, especially among learners with disabilities, including those with visual impairments in Nigerian inclusive school settings [1].

Despite inclusion-oriented frameworks such as Nigeria's Discrimination Against Persons with Disabilities (Prohibition) Act of 2018, learners with visual impairments continue to face systemic educational barriers. These include inaccessible instructional materials, inadequate teacher preparation, limited availability of assistive technologies, and insufficient institutional support for inclusive science education. This gap is particularly evident in science education, where diagrams, illustrations, experiments, and other visually dependent instructional approaches often limit the full participation of learners with visual impairments. Research has shown that achieving inclusive education requires not only supportive policies but also accessible learning technologies and instructional adaptations that accommodate diverse learning needs [2].

The advancement of assistive technologies, particularly screen readers, presents an opportunity to bridge this digital divide and support inclusive learning. NVDA (NonVisual Desktop Access), a free and open-source screen reader, enables individuals with visual impairments to access digital content, navigate computer applications, and interact with online learning environments through speech and keyboard commands. Unlike proprietary software such as JAWS, NVDA offers a cost-effective and sustainable solution for schools operating in resource-constrained environments, making it particularly suitable for many educational institutions in Nigeria. Beyond improving access to information, assistive technologies have been shown to enhance learners' autonomy, digital participation, and academic engagement .

Existing studies suggest that screen readers such as NVDA significantly improve access to digital learning resources, foster learner independence, and support academic participation among students with visual impairments [3]. Research conducted in higher education contexts demonstrates that NVDA enhances digital literacy, facilitates access to online learning platforms, and improves students' ability to complete academic tasks independently. Nevertheless, empirical evidence on the application of NVDA in secondary school climate change education remains limited, particularly within inclusive school settings in Nigeria where learners with visual impairments continue to experience significant barriers to science learning.

This study therefore investigates the impact of NVDA screen reader technology on the academic performance and engagement of visually impaired students in selected inclusive secondary schools in Kogi State, Nigeria. Specifically, the study examines whether integrating NVDA into the teaching of climate change concepts such as deforestation, pollution, flooding, and desertification improves learners' comprehension, participation, and overall learning outcomes [4]. The study contributes to the growing body of literature on inclusive science education by providing empirical evidence on the role of accessible digital technologies in promoting equitable climate change education for learners with visual impairments.

Objective of the Study

The general objective of this study was to evaluate the effectiveness of the NonVisual Desktop Access (NVDA) screen reader in enhancing climate change education among learners with visual impairment in selected inclusive secondary schools in Kogi State, Nigeria. Specifically, the study sought to:

a. Determine the effect of NVDA screen reader on the academic performance of visually impaired students in selected climate change concepts;
b. Examine the effect of NVDA screen reader on the engagement of visually impaired students during climate change instruction; and

c. Compare the learning outcomes of students taught climate change concepts using NVDA with those taught using conventional oral instructional methods [5].

Research Questions

The following research questions guided the study:

a. What is the effect of the NVDA screen reader on the academic performance of visually impaired students in selected climate change concepts?
b. What is the effect of the NVDA screen reader on the engagement of visually impaired students during climate change instruction?
c. How do the learning outcomes of visually impaired students taught climate change concepts using the NVDA screen reader compare with those of students taught using conventional oral instructional methods?

Hypotheses

The following alternate hypotheses guided the study:

H_1: There is a significant difference in the academic performance of visually impaired students taught climate change concepts using NVDA and those taught using conventional oral instructional methods.

H_2: There is a significant difference in the engagement levels of visually impaired students taught climate change concepts using NVDA and those taught using conventional oral instructional methods.

Materials and Methods

This study adopted a quantitative quasi-experimental research design to evaluate the effectiveness of the NonVisual Desktop Access (NVDA) screen reader in enhancing climate change education among visually impaired students in selected inclusive secondary schools in Kogi State, Nigeria. The study involved 83 senior secondary school students with visual impairment drawn from three inclusive schools. Participants were assigned to an experimental group (n = 41), which received instruction using the NVDA screen reader, and a control group (n = 42), which was taught using conventional oral instructional methods without assistive technology. The instructional intervention focused on selected climate change concepts, including deforestation, flooding, pollution, and desertification, and lasted for six weeks. A researcher-developed Climate Change Achievement Test (CCAT) and a Student Engagement Scale (SES) were used to collect data. The CCAT measured students' academic performance, while the SES assessed their level of engagement during instruction. Both instruments were subjected to face and content validation by experts in Science Education, Special Education, and Measurement and Evaluation to ensure their suitability for the study. A pilot study was conducted among visually impaired students from an inclusive secondary school outside the study area. The reliability of the CCAT was determined using the Kuder–Richardson Formula 20 (KR-20), which yielded a reliability coefficient of 0.82, while the internal consistency of the SES was established using Cronbach's alpha, resulting in a reliability coefficient of 0.86. These coefficients indicated that the instruments possessed adequate reliability for data collection. Pre-tests and post-tests were administered to both groups before and after the instructional intervention to assess changes in students' academic performance and engagement. Data were analysed using descriptive statistics to summarize participants' scores, while paired-sample t-tests and Analysis of Covariance (ANCOVA) were employed to determine the effect of the intervention at the 0.05 level of significance.

Results and Discussion

Results

Research Question One: What is the effect of the NVDA screen reader on the academic performance of visually impaired students in selected climate change concepts?

Table 1. Mean and Standard Deviation of Students' Pre-test and Post-test Achievement Scores

Group	N	Pre-test Mean	SD	Post-test Mean	SD	Mean Gain
Experimental (NVDA)	41	21.56	4.32	28.17	3.89	6.61
Control (Conventional Instruction)	42	21.43	4.18	24.10	4.03	2.67

The results presented in Table 4.1 show that the experimental and control groups had comparable academic performance before the intervention, with pre-test mean scores of **21.56 (SD = 4.32)** and **21.43 (SD = 4.18),** respectively. Following the six-week instructional intervention, students in the experimental group attained a higher post-test mean score of **28.17 (SD = 3.89)** compared with **24.10 (SD = 4.03)** for the control group. The experimental group also recorded a larger mean gain score (**6.61**) than the control group (**2.67**). This finding suggests that the use of the NVDA screen reader contributed substantially to improved academic performance among visually impaired students learning climate change concepts.

Research Question Two: What is the effect of the NVDA screen reader on the engagement of visually impaired students during climate change instruction?

Table 2. Mean and Standard Deviation of Students' Pre-test and Post-test Engagement Scores

Group	N	Pre-test Mean	SD	Post-test Mean	SD	Mean Gain
Experimental (NVDA)	41	31.18	5.41	42.34	5.26	11.16
Control (Conventional Instruction)	42	30.95	5.27	36.10	6.01	5.15

The results in Table 4.2 indicate that both groups had similar engagement levels before the instructional intervention, with mean scores of 31.18 (SD = 5.41) for the experimental group and 30.95 (SD = 5.27) for the control group. After the intervention, the experimental group recorded a higher post-test engagement mean score of 42.34 (SD = 5.26) than the control group, which obtained a mean score of 36.10 (SD = 6.01)**.** Furthermore, the experimental group achieved a mean gain score of **11.16**, compared with **5.15** for the control group. These findings indicate that using the NVDA screen reader enhanced students' engagement during climate change instruction by increasing their participation, attention, and involvement in classroom activities [6].

Research Question Three: How do the learning outcomes of visually impaired students taught climate change concepts using the NVDA screen reader compare with those of students taught using conventional oral instructional methods?

Table 3. Comparison of Learning Outcomes of Students Taught Using NVDA and Conventional Oral Instruction

Group	N	Post-test Mean	SD	Mean Difference
Experimental (NVDA)	41	28.17	3.89	4.07
Control (Conventional Instruction)	42	24.10	4.03	

Table 4.3 shows that visually impaired students who were taught climate change concepts using the NVDA screen reader achieved a higher post-test mean score (**28.17**, SD = **3.89**) than those who received conventional oral instruction (**24.10**, SD = **4.03**). The mean difference of **4.07** points in favour of the experimental group demonstrates that students exposed to NVDA achieved better learning outcomes. This finding suggests that integrating NVDA into climate change instruction is more effective than relying solely on conventional oral teaching methods [7].

Test of Hypothesis One: H_1: There is a significant difference in the academic performance of visually impaired students taught climate change concepts using NVDA and those taught using conventional instructional methods.

To test this hypothesis, Analysis of Covariance (ANCOVA) was conducted using the post-test achievement scores as the dependent variable, instructional group as the independent variable, and pre-test achievement scores as the covariate.

Table 4. ANCOVA Summary for Students' Academic Performance

Source	Sum of Squares	df	Mean Square	F	p-value
Group (NVDA)	131.02	1	131.02	10.87	0.0016*
Pre-test (Covariate)	84.47	1	84.47	7.01	0.0097*
Error	951.36	80	11.89		
Total	1166.85	82			

Significant at $p < 0.05$.

The ANCOVA results presented in Table 4.4 reveal that, after controlling for pre-test achievement scores, the instructional method had a statistically significant effect on students' academic performance, **$F(1, 80) = 10.87$, $p = 0.0016$**. Since the p-value is less than the 0.05 level of significance, the null hypothesis was rejected. This finding indicates that visually impaired students taught climate change concepts using the NVDA screen reader performed significantly better than those taught through conventional oral instruction [8], [9].

Test of Hypothesis Two: H_2: There is a significant difference in the engagement levels of visually impaired students taught climate change concepts using NVDA and those taught using conventional instructional methods.

Consistent with the quasi-experimental pre-test–post-test design, Analysis of Covariance (ANCOVA) was employed using post-test engagement scores as the dependent variable, instructional group as the independent variable, and pre-test engagement scores as the covariate.

Table 5. ANCOVA Summary for Students' Engagement

Source	Sum of Squares	df	Mean Square	F	p-value
Group (NVDA)	402.54	1	402.54	26.83	<0.0001*
Pre-test (Covariate)	91.86	1	91.86	6.12	0.0155*
Error	1200.13	80	15.00		
Total	1694.53	82			

Significant at $p < 0.05$.

The ANCOVA results in Table 4.5 indicate that, after adjusting for pre-test engagement scores, there was a statistically significant effect of the instructional method on students' engagement during climate change instruction, **$F(1, 80) = 26.83$, $p < 0.0001$**. Since the p-value is less than the 0.05 level of significance, the null hypothesis was rejected. This result indicates that students who received instruction using the NVDA screen reader were significantly more engaged than those taught using conventional oral instructional methods. The finding suggests that the integration of NVDA into classroom instruction promotes greater learner participation, attention, interaction, and motivation among visually impaired students [10].

Discussion

The findings of this study demonstrate that the integration of the NonVisual Desktop Access (NVDA) screen reader significantly enhanced the academic performance, engagement, and overall learning outcomes of visually impaired students in climate change education. The study compared students who received instruction using the NVDA screen reader with those taught through conventional oral instructional methods over a six-week period [11]. The results consistently favoured

the experimental group, indicating that the use of NVDA provided a more effective instructional approach for facilitating learning among visually impaired students.

Academic Performance: The findings revealed that students who were taught climate change concepts using the NVDA screen reader achieved significantly higher academic performance than those taught using conventional oral instructional methods. Although both groups demonstrated improvement from the pre-test to the post-test, the experimental group recorded a higher post-test mean score ($M = 28.17$, $SD = 3.89$) and a greater mean gain (6.61) than the control group ($M = 24.10$, $SD = 4.03$; mean gain = 2.67) [12]. Furthermore, the ANCOVA analysis showed that, after controlling for pre-test scores, the difference between the two instructional methods was statistically significant, $F(1, 80) = 10.87$, $p = 0.0016$. This finding suggests that the NVDA screen reader enhanced students' understanding of climate change concepts by providing independent and continuous access to digital learning materials through audio feedback. The ability to navigate instructional content autonomously likely improved comprehension, retention, and recall of information, thereby contributing to better academic achievement. The result agrees with the findings of Komolafe, who reported that the use of audio-based assistive technologies significantly improved the academic performance of visually impaired learners in Social Studies in Lagos State. Similarly, Okonji and Ogwezzy (2024) found that students who used the NVDA screen reader demonstrated improved reading proficiency, academic participation, and learning independence compared with students using other screen-reading technologies. These studies support the present finding that accessible digital technologies can significantly improve learning outcomes among visually impaired learners, particularly in resource-constrained educational environments [13], [14].

Student Engagement: The study also found that the use of the NVDA screen reader significantly improved students' engagement during climate change instruction. The experimental group recorded a higher post-test engagement mean score ($M = 42.34$, $SD = 5.26$) compared with the control group ($M = 36.10$, $SD = 6.01$), with corresponding mean gains of 11.16 and 5.15, respectively. The ANCOVA result further confirmed that the observed difference was statistically significant after controlling for pre-test engagement scores, $F(1, 80) = 26.83$, $p < 0.0001$. The higher engagement levels observed among students exposed to NVDA suggest that the technology encouraged greater participation, concentration, interaction with learning materials, and sustained attention during classroom instruction. The accessibility features of the screen reader likely reduced learning barriers and enabled students to participate more actively throughout the instructional process [15]. This finding corroborates the work of Adebayo and Salawu (2021), who reported that digital assistive technologies enhance learner motivation, participation, and inclusion among students with disabilities. Likewise, Olatunde-Aiyedun (2021) observed that technology-supported instruction promotes active learning by enabling learners with special educational needs to interact more effectively with instructional materials. Although these studies examined assistive technologies more broadly, their conclusions are consistent with the present study's finding that NVDA contributes positively to learner engagement.

Learning Outcomes: The comparison of learning outcomes further demonstrated that students taught using the NVDA screen reader performed better than those taught through conventional oral instruction. The experimental group attained a higher post-test mean score than the control group, with a mean difference of 4.07 points [16]. This finding indicates that integrating NVDA into climate change instruction resulted in better overall learning outcomes for visually impaired students. The improved learning outcomes observed in this study may be attributed to the interactive and accessible learning environment created through the use of NVDA. By enabling students to independently access electronic instructional materials and review lesson content at their own pace, the technology likely enhanced both understanding and long-term retention of climate change concepts. This finding is also consistent with the conclusions of Uyanwune et al. who reported that assistive technologies improve educational performance among learners with disabilities when effectively integrated into classroom instruction. However, the authors emphasized that the effectiveness of assistive technologies depends on adequate teacher preparedness, technical support, and learner training. Similarly, Okonji and Ogwezzy observed that limited awareness and insufficient training remain major barriers to the effective utilization of assistive technologies among visually impaired learners in Nigeria [17]. These

observations suggest that while NVDA has considerable instructional potential, its successful implementation requires sustained institutional support and capacity building for both teachers and students.

Relationship with Constructivist Learning Theory: The findings of this study support the assumptions of Constructivist Learning Theory, which posits that learners construct knowledge actively through meaningful interaction with learning materials and their environment. The NVDA screen reader provided visually impaired students with accessible and independent access to climate change instructional resources, thereby enabling them to engage actively in the learning process rather than relying solely on teacher explanations. Through self-paced navigation, repeated access to learning content, and increased interaction with instructional materials, students were able to construct a deeper understanding of climate change concepts [18]. The significant improvements observed in academic performance, engagement, and learning outcomes therefore provide empirical support for the application of constructivist principles in technology-assisted instruction for learners with visual impairment. The findings of this study provide strong evidence that the integration of the NVDA screen reader into climate change education significantly improves the academic performance, classroom engagement, and learning outcomes of visually impaired students in inclusive secondary schools. The findings are consistent with previous studies demonstrating the educational benefits of assistive technologies for learners with visual impairment. However, the literature also indicates that the full benefits of NVDA can only be realized when schools provide adequate technological infrastructure, teacher training, learner orientation, and continuous technical support. Consequently, the effective integration of screen reader technology should be accompanied by institutional commitment to inclusive educational practices to maximize its impact on learning.

Conclusion

This study investigated the effectiveness of the NonVisual Desktop Access (NVDA) screen reader in enhancing climate change education among visually impaired students in selected inclusive secondary schools in Kogi State, Nigeria. The findings revealed that students who received instruction using the NVDA screen reader achieved significantly higher academic performance than those taught through conventional oral instructional methods. The study also found that the use of NVDA significantly increased students' engagement during climate change instruction and resulted in better overall learning outcomes. The significant differences observed between the experimental and control groups indicate that integrating the NVDA screen reader into classroom instruction enhances visually impaired students' understanding of climate change concepts by providing accessible, independent, and interactive learning opportunities. These findings demonstrate that assistive technologies such as NVDA can play a vital role in promoting inclusive science education and improving educational outcomes for learners with visual impairments. Overall, the study concludes that the integration of NVDA screen reader technology is an effective instructional strategy for enhancing academic achievement, learner engagement, and learning outcomes among visually impaired students in climate change education. Its adoption in inclusive secondary schools has the potential to strengthen equitable access to quality science education and contribute to the achievement of inclusive educational practices.

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

Integration of Assistive Technology into Educational Policy: The Federal and State Ministries of Education should develop and implement policies that promote the integration of assistive technologies, particularly the NVDA screen reader, into science instruction in inclusive secondary schools. Capacity Building for Teachers: Science teachers and special education teachers should receive regular professional development and hands-on training on the effective use of NVDA and other assistive technologies to enhance instructional delivery for visually impaired learners. Development of Accessible Instructional Materials: Curriculum developers, examination bodies, and educational publishers should provide climate change and other science instructional materials in accessible digital formats that are compatible with screen reader technologies.

Provision of ICT Infrastructure: Governments, school proprietors, and educational stakeholders should provide adequate ICT facilities, including computers, headphones, electricity, and other NVDA-

compatible devices, to support effective implementation of assistive technology in inclusive schools. Technical Support and Maintenance: Schools should establish technical support systems to ensure the installation, maintenance, and regular updating of NVDA software and related assistive technologies for uninterrupted classroom use. Learner Orientation and Digital Literacy: Visually impaired students should be provided with regular orientation and training on the effective use of NVDA and other assistive technologies to maximize their learning experiences and academic performance. Future researchers should investigate the long-term effects of NVDA and other assistive technologies on students' academic performance, engagement, and retention across different science subjects, educational levels, and geographical locations. Comparative studies involving other screen readers and assistive technologies are also recommended to broaden the evidence base for technology-supported inclusive education.

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