INNOVATIVE TECHNOLOGY AND PEDAGOGICAL APPROACHES ADOPTIONS IN ACHIEVING SUSTAINABLE DEVELOPMENT: PERSPECTIVE OF SCIENCE EDUCATORS IN NIGERIA

ADOPSI TEKNOLOGI INOVATIF DAN PENDEKATAN PEDAGOGIS DALAM MENCAPAI PEMBANGUNAN BERKELANJUTAN: PERSPEKTIF PENDIDIK SAINS DI NIGERIA

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ABSTRAK

Penelitian ini menyelidiki bagaimana pendidik sains di universitas-universitas Nigeria menggunakan alat-alat canggih dan teknik pengajaran untuk mempromosikan pembangunan berkelanjutan. Di Ilorin, Negara Bagian Kwara, 45 pendidik sains dari universitas negeri dan swasta berpartisipasi dalam survei deskriptif dengan menggunakan kuesioner terstruktur yang terdiri dari 25 item. Penelitian ini mengevaluasi tingkat adopsi teknologi baru, jenis strategi pedagogis yang digunakan, dan kesulitan yang dihadapi oleh para pengajar saat menggunakan taktik ini. Temuan penelitian menunjukkan bahwa meskipun dukungan institusional terhadap proyek-proyek ini masih terbatas, terdapat tingkat adopsi teknologi yang moderat seperti papan tulis interaktif dan aplikasi pembelajaran mobile. Meskipun pendekatan pedagogis seperti pembelajaran berbasis penyelidikan dan berbasis proyek sering digunakan, masih ada peluang untuk mencapai keseragaman yang lebih besar di antara para pengajar. Masalah utama yang tercatat adalah resistensi fakultas dan mahasiswa terhadap perubahan, kurangnya kesempatan pengembangan profesional, serta akses yang tidak memadai terhadap sumber daya. Untuk berhasil mengintegrasikan teknologi canggih dan strategi pengajaran untuk pendidikan keberlanjutan, penelitian ini menekankan pentingnya memperkuat dukungan institusional, menawarkan program pelatihan yang lebih menyeluruh, dan mengatasi resistensi tersebut.

ABSTRACT

This study investigated how science educators in Nigerian universities use cutting-edge tools and instructional techniques to promote sustainable development. In Ilorin, Kwara State, 45 science educators from public and private universities participated in a descriptive survey using a 25-item structured questionnaire. The study evaluates the degree of new technology adoption, the kinds of pedagogical strategies used, and the difficulties teachers encounter while using these tactics. The findings suggest that although there is still little institutional support for these projects, there is a moderate level of adoption of technology such as interactive whiteboards and mobile learning apps. Although pedagogical approaches like inquiry-based and project-based learning are frequently used, more uniformity among teachers could still be achieved. The main issues noted are faculty and student resistance to change, a lack of professional development opportunities, and inadequate access to resources. In order to successfully integrate cutting-edge technologies and instructional strategies for sustainability education, the study emphasizes the significance of bolstering institutional support, offering more thorough training programs, and resolving resistance.

INTRODUSTION

One of the most innovative areas of education is education for sustainable development (ESD). It naturally draws from long-standing progressive educational traditions and emulates innovative education elsewhere, just like in many other fields. Any new technological development is based on science. According to Kalagbor (2022), science is a methodical and structured body of knowledge that deals with how people perceive their own national capacities. A person who lacks scientific and technology literacy is significantly limited in his ability to contribute to the socioeconomic advancement of his community in the modern world (Obinyan & Aziegbe, 2018).

According to Jolaoluwa et al. (2024), science education functions as a bridge that connects many branches of knowledge. According to Ezenwa et al. (2021), science education is a process of instruction or training, particularly in schools, to enhance one's understanding of the environment, cultivate one's capacity for methodical inquiry, and cultivate one's innate attitudes.

An interdisciplinary approach is promoted by science education, which promotes cooperation and idea integration (Jolaoluwa et al., 2024). Science education is essential for educating pupils for the problems of the twenty-first century, claim Wang et al. (2021). It enables them to engage in scientific discussions in society and gives them the skills they need to handle complicated scientific topics like genetic engineering and climate change. To encourage curiosity, creativity, and critical thinking, science instruction should be inclusive, interesting, and applicable to students' daily life (Obe & Oladepo, 2023).

Students who study physics, chemistry, biology, educational technology, and mathematics gain a comprehensive viewpoint that helps them address difficult global issues including resource depletion, climate change, and public health emergencies. Teaching and learning about scientific concepts, principles, methods, and applications is known as science education. It seeks to foster students' enthusiasm in science, scientific literacy, and critical thinking abilities. Science education helps people become knowledgeable citizens who can make logical, evidence-based judgments and lays a solid platform for future scientific professions (Jolaoluwa et al., 2024).

Both topic knowledge and the growth of scientific inquiry abilities are components of an effective science education (Van Driel, 2021). It entails observation, data analysis, practical experimentation, and sharing scientific discoveries. Students gain problem-solving abilities and learn how to think like scientists by participating in scientific activities. There are many advantages to including pupils in science education. It encourages curiosity, helps pupils cultivate a growth mentality, and advances a deeper grasp of the natural world. Additionally, it fosters abilities like creativity, critical thinking, teamwork, and communication, all of which are important for promoting sustainable development in Nigeria (Jolaoluwa et al., 2024). Sustainable development, according to Abiogu and Ogoke (2020), is a strategy that balances the requirements and goals of current development with those of the future without sacrificing ecological integrity. In order to prepare the world community to handle the new challenges brought about by environmental changes worldwide, sustainable development is a crucial concern (Obe & Oladepo, 2023).

It is impossible to overstate the significance of sustainable development for any organization. Universities had adopted a number of strategies for rethinking sustainable development by the beginning of the UNESCO Decade of Education for Sustainable Development (Agbedahin, 2019). All academic levels and disciplines at the institution must undergo a significant transition (Franco et al., 2019). The ultimate goal of academic teaching programs focused on "sustainability," according to Magd and Bystroy (2021), is to assist in the practical realization of a sustainable future for business, industry, and society. The Sustainable Development Goals (SDGs), which are both an approach to sustainable development and a tool for collaboratively addressing global problems, require universities and their stakeholders, students, staff, scholars, administration and management, research communities, alumni, businesses, social movements, consumer organizations, governments, and professional associations to reconsider the idea of university education for sustainable development more than ever before (Obe & Oladepo, 2023).

According to Walii and Okai (2019), sustainable development is a concept that views development as satisfying the requirements of the current generation without sacrificing those of future generations. It suggests that even though education satisfies current wants, it does not jeopardize the

capacity of future generations to satisfy their own. However, both physical capital (machine, tool, etc.) and human capital (education, technological advancement) decide this capacity to meet the needs. According to Walii and Okai (2019), sustained sustainable development can only be achieved or guaranteed when there is agreement and actual action made to improve literacy and numeracy in every community. Thus, Nigerian universities and their curricula serve as the means of achieving innovation, sustainability, and development (Ogunode, 2020).

The introduction of innovation is intended to ensure efficiency and boost productivity, and it has been characterized as structured and risk-taking. It entails both establishing new conditions and adjusting to existing ones (Modranský et al., 2020). Innovations are tools for achieving goals rather than ends in and of themselves. To put it simply, an innovation is the introduction of new concepts, procedures, and technology that will fundamentally transform the company (Chikati, 2019). With new methods and original concepts, innovation is a transformation overhaul that aims to support the success of the science education curriculum. It also serves as a way to modify what should be done and how to do it in order to meet objectives in the planned science education curriculum for sustainable development (Walii & Okai, 2019). In addition to introducing new technologies and trends in scientific education, innovation fosters creativity and the ability to think creatively about how to make science curricula in Nigerian universities serve a purpose and contribute to sustainable development (Okori & Ebere, 2019).

Promoting these educational objectives has required the use of cutting-edge pedagogical strategies like problem-based learning, experiential learning, and technological integration (Aunzo, 2025). By encouraging students to tackle real-world environmental issues, problem-based learning improves their critical thinking and problem-solving skills. Field trips and community service initiatives are examples of experiential learning that gives students hands-on experience with sustainable methods and environmental preservation. Through the use of digital tools and online platforms, technology has further increased the efficacy and accessibility of these educational initiatives, resulting in more dynamic and captivating learning (Huda, 2023). Adopting these teaching strategies has also been made possible in large part by teacher preparation. Programs for professional development have been established to guarantee that teachers possess the information and abilities needed to successfully communicate sustainability principles (Memon & Memon, 2025). Educating teachers on contemporary teaching techniques, incorporating sustainability into the curriculum, and using creative approaches to engage and engage students are the goals of these programs.

Managing Digitalization of Secondary Education for Sustainable Development in Imo State, Nigeria, a research by Mba and Adieme (2024), explores how digital tools in secondary education might be efficiently managed to promote sustainable development. The study emphasizes how effective management of digital resources and the development of teachers' digital abilities are critical to the successful integration of digital technology into the educational process. This strategy is thought to be crucial for creating an educational setting that backs efforts for sustainable development. Science Educators' Pedagogical Practices for Sustainability in Teacher Education Programs in the Face of COVID-19 Pandemic by Okeke and Yusuf (2022) is another enlightening study that looks at how science educators modified their teaching strategies to ensure sustainability in teacher education programs during the COVID-19 pandemic.

The study emphasizes how crucial creative teaching methods and technology utilization are to upholding academic standards and encouraging sustainable development in these extraordinary times. Additionally, the contribution of science education in Nigerian tertiary institutions to the achievement of the Sustainable Development Goals (SDGs) is examined in the paper Achieving Sustainable Development Goals through Effective Teaching of Science Education in Nigeria Tertiary Institutions by Adewale and Oladipo (2023). The study highlights how crucial it is to implement efficient teaching strategies and incorporate sustainability-related subjects into the science curriculum. The goal of this method is to provide students the information and abilities they need to take an active role in sustainable development initiatives. The study examined the adoption of innovative technology and pedagogical approaches in attaining sustainable development from the viewpoint of science educators in Nigerian universities, drawing on the reviewed literature.

Purpose of the Study

The main purpose of this study was to investigate the innovative technology and pedagogical approaches adoptions in achieving sustainable development: perspective of science educators in Nigeria universities. Specifically, the study aimed to;

1. determined the extent to which science educators in Nigerian universities have adopted innovative technologies for promoting sustainable development;
2. determined the extent to which science educators in Nigerian universities have adopted pedagogical approaches for promoting sustainable development;
3. find out the specific types of innovative technologies being implemented by science educators to enhance sustainability in education;
4. find out the specific types of pedagogical approaches being implemented by science educators to enhance sustainability in education;
5. examined the challenges faced by science educators in integrating innovative technologies and pedagogical strategies into their teaching for sustainability.

Research Question

1. What is the extent to which science educators in Nigerian universities have adopted innovative technologies for promoting sustainable development?
2. What is the extent to which science educators in Nigerian universities have adopted pedagogical approaches for promoting sustainable development?
3. What are the specific types of innovative technologies being implemented by science educators to enhance sustainability in education?
4. What are the specific types of pedagogical approaches being implemented by science educators to enhance sustainability in education?
5. What are the challenges faced by science educators in integrating innovative technologies and pedagogical strategies into their teaching for sustainability?

RESEARCH METHODE

This study used an organized methodology to examine how science instructors in Nigerian universities see the adoption of cutting-edge pedagogical and technological approaches in attaining sustainable development. In order to learn more about the extent to which science educators have adopted innovative technology and pedagogical approaches, the types of innovative technology and pedagogical approaches that have been implemented, and the difficulties they have encountered in incorporating these strategies into their teaching for sustainability in Nigerian universities, a descriptive survey design was employed. The study focused on science instructors in Ilorin, Kwara State's public and private universities. One university from each of the federal, state, and private sectors was chosen using purposive sampling. To ensure a diverse educational representation, 45 science educators with 25 men and 35 women were selected by random sampling.

A 25-item Likert scale survey called "Innovative Technology and Pedagogical Approaches Adoptions in Achieving Sustainable Development: Perspective of Science Educators in Nigeria Universities" was used to collect the primary data. While Section B concentrated on the degree of adoption of innovative technology, pedagogical approaches, types of innovative technology, types of pedagogical approaches implemented, and challenges encountered in integrating innovative technology and pedagogical approaches, Section A collected demographic information. Five research questions posed for this study were addressed using this questionnaire. The variable time frame for data collection was September 2024–January 2025. Four renowned instructors with knowledge of the subject matter validated the questionnaire. The instrument received a reliability coefficient of 0.81 after being put through a reliability test utilizing the split-half reliability technique. Statistical Product and Service Solution (SPSS) version 23 was used to analyze the data, and descriptive statistics such as means and standard deviations were used. The conclusions for the study's justification were derived from the findings.

RESULT AND DISUSSION

Research Question 1: What is the extent to which science educators in Nigerian universities have adopted innovative technologies for promoting sustainable development?

Table 1. The extent to which science educators in Nigerian universities have adopted innovative technologies for promoting sustainable development

S/N	ITEMS	MEAN	ST.D
1	I use innovative technologies in my teaching to address sustainable development topics.	2.60	0.80
2	The curriculum in my university incorporates innovative technologies as a key component for teaching sustainable development.	3.00	0.63
3	I am proactive in adopting new technologies to enhance sustainability education.	2.80	0.76
4	My university encourages and supports science educators in integrating innovative technologies for sustainable development.	2.60	0.49
5	The adoption of innovative technologies by science educators has become a standard practice in my university for promoting sustainable development.	2.80	0.40

Source: Field Work, 2025

The results presented in Table 1 provide important information about the extent to which science instructors in Nigerian universities are using innovative technologies to support sustainable development. The average scores for all items point to a moderate degree of adoption, with the first item's mean score of 2.60 suggesting that although some teachers use innovative technologies in their instruction to address sustainable development, this is not yet a standard practice. A more structured institutional approach is reflected in the second item's higher mean of 3.00, which indicates a comparatively stronger presence of innovative technology inside the university curriculum. Although there is certainly opportunity for improvement, the third item's mean score of 2.80 indicates that many instructors consider themselves proactive in embracing new technology.

Overall, the data shows a moderate level of integration of innovative technologies by science educators. The fourth item, which also has a mean of 2.60, indicates that there is moderate institutional support, indicating that more could be done to provide better support systems for educators. While the adoption of innovative technologies is gradually becoming more routine, it has not yet achieved uniform or widespread application among all educators, according to the fifth item, which has a mean of 2.80. While some areas, such as curriculum integration and educators' proactive adoption, demonstrate encouraging levels of engagement, the uneven standardization and moderate institutional support underscore the need for additional work to fully integrate these technologies into teaching practices that promote sustainable development.

Research Question 2: What is the extent to which science educators in Nigerian universities have adopted pedagogical approaches for promoting sustainable development?

Table 2. The extent to which science educators in Nigerian universities have adopted pedagogical approaches for promoting sustainable development

S/N	ITEMS	MEAN	ST.D
1	I consistently adopt pedagogical approaches that emphasize sustainable development in my teaching.	2.80	0.76
2	Innovative pedagogical methods focused on sustainable development are frequently used by me.	3.40	0.49
3	The teaching strategies employed by me are designed to promote critical thinking about sustainable development issues.	3.40	0.49
4	My university supports science educators in implementing pedagogical approaches that foster sustainable development.	3.40	0.49
5	I am well-versed in using diverse pedagogical methods to integrate sustainable development concepts into my lessons.	3.00	0.00

Source: Field Work, 2025

The results presented in Table 2 shed light on the degree to which science instructors in Nigerian universities have adopted pedagogical strategies that support sustainable development; the mean scores show a high degree of adoption, with some areas showing high engagement. The first item, with a mean score of 2.80, indicates that although many teachers regularly use pedagogical strategies that prioritize sustainable development, there is still room for wider implementation. A substantial emphasis on

innovative teaching methods, encouraging critical thinking about sustainability, and receiving institutional support for these pedagogical strategies is highlighted by items two, three, and four, each of which has a mean score of 3.40. These findings imply that educators are not only embracing cutting-edge techniques but are also supported by their institutions in incorporating these approaches.

With a mean score of 3.00, the fifth item shows that teachers are confident in their capacity to integrate sustainable development principles into their classes using a range of pedagogical approaches. This indicates a solid basis in the abilities and know-how required to successfully apply a variety of teaching techniques. In conclusion, the findings show a strong uptake of teaching strategies meant to promote sustainable development. Teachers receive adequate training and assistance, with a focus on creative problem-solving and critical thinking. Nonetheless, ongoing efforts are required to guarantee that these principles are uniformly implemented everywhere.

Research Question 3: What are the specific types of innovative technologies being implemented by science educators to enhance sustainability in education?

Table 3.The specific types of innovative technologies being implemented by science educators to enhance sustainability in education

S/N	ITEMS	MEAN	ST.D
1	I frequently use digital simulations and virtual labs to teach sustainability concepts.	2.00	0.56
2	Learning management systems (LMS) are widely utilized by me to support sustainability education.	2.31	0.76
3	Interactive whiteboards and smart technologies are commonly employed by me to enhance sustainability lessons.	3.18	0.89
4	Mobile learning applications are integrated into the teaching practices of science educators to promote sustainability.	3.64	0.52
5	I often incorporate data visualization tools and software to illustrate sustainability challenges and solutions.	2.00	0.56

Source: Field Work, 2025

The results in Table 3 provide information about the particular kinds of cutting-edge technologies that science teachers are implementing to improve sustainability in the classroom. The average scores show that different technologies are used to differing degrees. With a mean score of 2.00, the first item indicates that virtual labs and digital simulations are not widely used, suggesting a limited integration of these resources into instructional strategies. A slightly higher but still moderate use of learning management systems (LMS) to promote sustainability education is shown by the second item, which has a mean score of 2.31. This indicates that LMS technologies are becoming more and more popular, yet not yet widely used. On the other hand, the third item, which has a mean of 3.18, indicates that smart technology and interactive whiteboards are used more frequently, indicating that these resources are now a more important component of teachers' approaches to teaching sustainability.

The fourth item, which has the highest mean (3.64), shows that mobile learning applications are widely used, emphasizing how frequently they are incorporated into instructional strategies and how mobile technology is used to advance sustainability ideas. Last but not least, the fifth item, like the first, has a mean of 2.00, implying that there is a great deal of space for greater adoption of these technologies. This indicates that data visualization tools and software are not commonly utilized to communicate sustainability concerns and solutions. Overall, the findings show that science teachers are adopting new technologies in a variety of ways. While interactive whiteboards and mobile learning apps are more frequently used, digital simulations, virtual labs, and data visualization tools are less frequently used. This identifies areas where technology use in sustainability education could be improved through additional development and integration.

Research Question 4: What are the specific types of pedagogical approaches being implemented by science educators to enhance sustainability in education?

Table 4. The specific types of pedagogical approaches being implemented by science educators to enhance sustainability in education

S/N	ITEMS	MEAN	ST.D
1	I frequently use project-based learning to engage students in sustainability-related topics.	3.51	0.50
2	Inquiry-based learning is a common pedagogical approach adopted by me to explore sustainability issues.	3.76	0.43
3	Collaborative learning methods are regularly implemented by me to promote discussions on sustainability.	3.62	0.49
4	I incorporate experiential learning activities, such as field trips and hands-on projects, to teach sustainability.	3.51	0.50
5	Problem-solving and critical thinking exercises focused on sustainability challenges are integral to the teaching strategies used by me.	3.62	0.49

Source: Field Work, 2025

Table 4's results show the particular pedagogical strategies being used by science teachers to advance sustainability in the classroom. The findings show a high level of adoption of various instructional strategies. With a mean score of 3.51, the first item indicates a strong preference for practical, hands-on teaching methods and indicates that project-based learning is frequently used to introduce students to sustainability topics. With the highest mean score of 3.76, the second item highlights how inquiry-based learning is widely used. Science educators seem to value teamwork and collective problem-solving in addressing environmental challenges, as evidenced by the third item's mean score of 3.62, which highlights the regular use of collaborative learning methods that foster discussions and group work on sustainability-related subjects. This approach encourages students to investigate sustainability issues through inquiry and questioning, and it seems to be a foundational method in sustainability education for science educators. Field trips and practical projects are examples of experiential learning activities that are frequently included in the curriculum, as evidenced by the fourth item, which similarly has a mean of 3.51. Students' comprehension of sustainability topics is strengthened by these hands-on, real-world experiences. With a mean score of 3.62, the last item highlights the incorporation of critical thinking and problem-solving activities that center on environmental issues. This suggests that teachers give careful consideration to helping pupils develop the analytical skills necessary to tackle and resolve challenging environmental issues. All things considered, the findings imply that science instructors are successfully advancing sustainability teaching using a variety of instructional strategies. The consistently high mean ratings for all of these approaches show a strong and all-encompassing strategy for developing students' sustainability knowledge and abilities.

Research Question 5: What are the challenges faced by science educators in integrating innovative technologies and pedagogical strategies into their teaching for sustainability?

Table 5.The challenges faced by science educators in integrating innovative technologies and pedagogical strategies into their teaching for sustainability

S/N	ITEMS	MEAN	ST.D
1	Science educators in my university face significant challenges in accessing the necessary technological resources to teach sustainability.	3.51	0.50
2	Limited training and professional development opportunities hinder science educators from effectively integrating innovative technologies into their teaching for sustainability.	3.76	0.43
3	The lack of institutional support and funding makes it difficult for science educators to incorporate new pedagogical strategies for sustainability.	3.62	0.49
4	Time constraints and heavy workloads prevent science educators from fully adopting innovative technologies and pedagogical approaches for sustainability education.	3.51	0.50
5	Resistance to change among colleagues and students is a major barrier to integrating innovative technologies and pedagogical strategies for sustainability in my university.	3.62	0.49

Source: Field Work, 2025

When it comes to integrating cutting-edge technologies and pedagogical strategies for sustainability education, science educators face a number of obstacles, as indicated by the mean scores in Table 5. The first item, with a mean score of 3.51, indicates that teachers face a significant challenge when it comes to teaching sustainability: a lack of access to necessary technological resources. This highlights the need for improved technology provision and availability in educational settings. With the highest mean of 3.76, the second item shows that teachers' capacity to incorporate cutting-edge technologies into their lesson plans is severely hampered by a lack of professional development opportunities and insufficient training. This suggests that more thorough and organized training programs are required to equip teachers with the know-how to successfully integrate technology into sustainability instruction.

With a mean score of 3.62, the third item suggests that teachers' adoption of innovative teaching techniques is further hampered by a lack of institutional funding and support. This emphasizes how crucial it is to have institutional support and funding in order to facilitate the adoption of sustainable teaching methods. Time constraints and excessive workloads are another obstacle to fully integrating modern technologies and educational techniques, as highlighted by the fourth item, which has a mean score of 3.51.

Teachers frequently have conflicting demands on their time, which restricts their ability to experiment with and incorporate novel teaching strategies. Lastly, the fifth item, which has a mean score of 3.62, indicates that students' and colleagues' resistance to change is a major problem. This suggests that in order to overcome this resistance and promote the adoption of cutting-edge methods in sustainability education, there needs to be a mental shift and an openness to new ideas. Overall, the findings highlight a number of significant obstacles that science teachers must overcome in order to include cutting-edge technologies and sustainable teaching methods. These difficulties include time constraints, resistance to change, a lack of institutional support, poor professional development, and restricted access to resources. Improving the efficacy of sustainability education in Nigerian colleges requires addressing these problems.

Discussion

In order to support sustainable development in Nigerian institutions, the study's conclusions offer insightful information about how cutting-edge technologies and instructional strategies might be included into science curricula. The dynamic field of education for sustainable development, or ESD, combines cutting-edge tactics to raise awareness of sustainability with more conventional progressive methods. As the cornerstone of technological progress, scientific education is essential for giving students the information and abilities they need to tackle global issues including resource depletion, climate change, and public health emergencies (Jolaoluwa et al., 2024). According to the report, although Nigerian university instructors are progressively integrating cutting-edge technologies into their lesson plans, the general level of adoption is still modest.

This implies that even if advancements are being made, the process of fully integrating these technologies is still ongoing. The results show that teachers are actively embracing new technology and are actively involved in curricular integration. The need for more coordination and consistency is highlighted by the persistence of issues like uneven implementation and moderate institutional support. These findings are consistent with Kalagbor's (2022) assertion that science is the cornerstone of technological advancement and is essential for developing the critical thinking abilities required to tackle sustainability concerns. High mean scores across a range of teaching techniques demonstrate that pedagogical tactics targeted at promoting sustainability are well-established at Nigerian universities, according to the study. There is a major emphasis on practical, hands-on teaching methods, as evidenced by the widespread adoption of approaches like project-based learning, inquiry-based learning, and experiential learning.

These approaches not only foster critical thinking and problem-solving abilities but also give students the resources they need to address environmental issues in the real world. The results are consistent with Wang et al.'s (2021) assertion that students should be prepared to tackle challenging scientific issues. The study does, however, identify a number of significant barriers that prevent the successful fusion of cutting-edge technologies with instructional strategies. The main obstacles include things like time limits, aversion to change, lack of institutional support, restricted access to technical

resources, and inadequate professional development opportunities. These difficulties align with the findings of Okeke and Yusuf (2022), who emphasize the significance of improving teacher preparation and managing digital resources in order to advance sustainability education.

The importance of digital technologies and teacher education in accomplishing sustainable development goals in education is also highlighted by Mba and Adieme's (2024) research. Improving the efficacy of sustainability education requires addressing these issues. Facilitating the successful integration of innovative technologies and teaching approaches requires strengthening institutional support, increasing access to resources, and offering educators more comprehensive and continuous professional development. Furthermore, overcoming resistance to change and guaranteeing the broad adoption of these cutting-edge teaching techniques will depend on encouraging a more adaptable and open mentality in both teachers and pupils.

CONCLUSION

The study's conclusions show that Nigerian institutions' incorporation of cutting-edge technologies and pedagogical techniques for sustainability teaching has both strengths and room for development. Although science teachers' use of cutting-edge technologies is quite minimal, there is unmistakable growth in areas like proactive adoption and curriculum integration. To completely integrate new technologies into instructional strategies meant to advance sustainable development, the results also emphasize the necessity of more uniform institutional support and uniformity across the board. The study also shows a high uptake of teaching strategies that support sustainability. With their creative approaches and emphasis on critical thinking, educators seem well-prepared and supported. Nonetheless, it is clear that ongoing work is necessary to guarantee that these teaching strategies are applied consistently throughout the larger educational community.

In terms of technology, the study finds that different tools are adopted at different rates. Interactive whiteboards and mobile learning applications are more regularly used, but digital simulations, virtual labs, and data visualization tools are less often integrated. This identifies areas in which additional training and development could improve the use of these technologies in sustainability education. Although there have been encouraging developments in the use of instructional techniques, the study also identifies a number of important obstacles. These include time limits, resistance to change, a lack of institutional support, restricted access to technology resources, and insufficient opportunities for professional development. To increase sustainability education's overall efficacy and reach in Nigerian universities, these obstacles must be removed.

Recommendations

1. Nigerian universities should improve the integration of innovative technologies into the science education curriculum by increasing institutional support and providing faculty with up-to-date resources.
2. Universities should invest in comprehensive professional development programs to equip science educators with advanced teaching methods that promote sustainable development.
3. Universities should encourage the widespread use of mobile learning applications and interactive whiteboards by offering incentives for educators and ensuring access to necessary devices.
4. Universities should secure funding and establish resource centers to ensure science educators have access to the technological tools needed for effective sustainability education.
5. Universities should promote a culture of openness to new pedagogies by encouraging dialogue and leadership support to overcome resistance to change in teaching methods.

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