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ASSESSING THE IMPACT OF GREEN TECHNICAL, VOCATIONAL EDUCATION AND TRAINING AND ARTIFICIAL INTELLIGENT ADOPTION ON SUSTAINABLE DEVELOPMENT OUTCOMES IN OGUN STATE TECHNICAL COLLEGES

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Abstract

This study examined the impact of Green Technical and Vocational Education and Training (TVET) and Artificial Intelligence (AI) in promoting sustainable development in technical colleges in Ogun State, Nigeria. It assessed the level of adoption of green practices and AI technologies, and their influence on environmental awareness, resource management, and students' employability. A survey research design was adopted, involving 300 respondents comprising teachers, administrators, and senior students selected through stratified random sampling. Three hundred (300) questionnaire were generated to elicit response from respondents. Data were collected using the validated Green TVET and AI Integration Assessment Questionnaire (GTAIAQ) and analyzed using descriptive and inferential statistics. Alpha basis where a reliability coefficient of 0.70 or above is accepted. Findings revealed a moderate to high adoption of green TVET practices, particularly in environmental sustainability and green entrepreneurship, although gaps exist in eco-friendly instructional resources and renewable energy training. AI adoption was also moderate, with common applications including personalized learning and AI-powered assessment tools. However, inadequate infrastructure, financial constraints, policy limitations, and resistance to change hinder effective implementation.The study concluded that integrating Green TVET and AI significantly enhances sustainable development outcomes. It recommended increased investment in digital infrastructure, capacity building, and stronger collaboration among stakeholders to support effective implementation.

Keywords: Green TVET, Artificial Intelligence, Sustainable Development, Technical Colleges

Introduction

The impetus to sustainable development itself has brought a new paradigm shift in education sector particularly in the field of delivery, application and alignment of the new knowledge as well as skill base on the changing needs of the 21 st century workforce. Following the growing demands of concern in climate change, loss of biodiversity, and degradation of the environment, as well as disparities of socio-economic growth, it has become a matter of agreement among policy-makers, educators, and development partners that learning should bear a central role in ensuring competencies are imbibed in learners that foster responsibilities of the environment, economic strengths and, social inclusion. This puts a strain on the educational systems to not only to have the ability to teach technical expertise but also to teach values and practices that facilitate sustainable development (Droubi, Galamba, Fernandes, De Mendonca & Heffron (2023).

Technical and Vocational Education and Training (TVET) has also been identified as an important tool of producing technical skills and practical abilities required in the industrial and technological advancements. But as in the context of sustainable development, TVET has also increased the role to include the promotion of green skills, which are competencies that lead to environmental preservation, energy frugality, sustainable production, and responsible use of the resources. This is commonly discussed as Green TVET which can be said as orienting vocational education on environmental sustainability through development of an environmentally literate and workforce rendering them competent in environmental matters. UNESCO (2022) underlines that Green TVET is vital in enabling just transition to green economies and sustainable communities, exposing learners to the skills needed

to be able to work in green professions in sectors like renewable energy, agriculture, eco-construction and waste recycling.

At the same time, digital revolution, which is spurred by Artificial Intelligence (AI), is transforming educational service, learning experience and institutional management. Smart tools are currently being enabled by AI to optimize teaching effectiveness by intelligent tutoring systems, learning analytics, predictive modeling, automated evaluations, and individualized learning ecosystems. The technologies have offered a chance of efficiency, access, and inclusiveness in education and especially among individuals pursuing tech-related courses. The application of AI in TVET can address infrastructure, ensure innovation in delivery and enhancement of the decision-making process and efficiency in technical institutions (Mutlu Cukurova *et al*.. 2021).

The situation in developing countries such as Nigeria, where schools, colleges, and other learning institutions continue to face numerous challenges—including infrastructural deficits, outdated curricula, inadequate teacher capacity, and high youth unemployment—presents a critical opportunity for transformative interventions through the integration of Green Technical and Vocational Education and Training (TVET) and Artificial Intelligence (AI) (World Bank, 2020; UNESCO, 2021). Ogun State in southwestern Nigeria exemplifies both these challenges and emerging opportunities. The state is strategically positioned near Lagos State, the nation's commercial hub, and is characterized by a high concentration of technical colleges and a growing population of youth seeking employable skills. Despite these advantages, Ogun State faces increasing environmental challenges, including land degradation, poor waste management, and deforestation, which require urgent and sustainable solutions. The integration of Green TVET and AI-driven innovations offers a viable pathway to address these socio-economic and environmental issues by promoting sustainable skills development, enhancing instructional delivery, and fostering environmentally responsible practices (OECD, 2021; Holmes et al., 2019).

So, although the understanding of green skills and AI innovations is becoming more and more popular, there still lacks the empirical evidence concerning how these approaches have been already adopted in technical colleges of Ogun State. Little is known about the extent to which flow-on impacts generated by these interventions are measurably contributing to a sustainable development future, in practice through improved environmental stewardship in students, lower carbon levels of their institutions, their subsequent employability in the green economy where they work, and their greater access to a higher-quality education that can be afforded, thanks to AI-enhanced teaching. Moreover, there is not a lot to understand concerning the problems that oppose the successful integration of Green TVET and AI, such as policy limitations, shortage of financing, change opposition, and capacity shortage (OECD, 2021; Holmes et al., 2019).

As such, this research study endeavors to fill this gap in knowledge by evaluating the effects of Green TVET and adoption of AI on sustainable development outcome in Ogun State technical colleges. It examines what is the degree to which green and AI integration are used, what they contribute to the sustainability-related metrics, as well as what the inhibitors and predisposing factors conditioning their application are. It is envisaged that the study will create evidence-based knowledge that will guide education policymakers, curriculum developers, school administrators, and development partners on how they can shore up the role of TVET toward a sustainable development agenda of Nigeria. Finally, the results will be involved in the development of a sustainable economy, environment-friendly workforce, empowered technologically, and world-ready productive work environment.

Statement of the Problem

The growing challenges of environmental degradation and rapid technological advancement have intensified the need for Technical and Vocational Education and Training (TVET) systems to adopt innovative and sustainable approaches. Globally, Green TVET and Artificial Intelligence (AI) are recognized as key drivers of sustainable development, as they promote environmentally responsible skills, enhance teaching and learning processes, and improve workforce readiness for emerging green industries. Despite these potentials, many technical colleges in Ogun State, Nigeria, continue to operate with outdated curricula, limited integration of green practices, and inadequate utilization of AI technologies.

This situation raises concerns about the ability of these institutions to adequately prepare students for the demands of a modern, technology-driven, and environmentally conscious labour market. Furthermore, although policy attention toward sustainability and digital transformation in education is increasing, there is a lack of empirical evidence on the extent of integration, effectiveness, and challenges of implementing Green TVET and AI in technical colleges within the state.

The absence of such data limits informed decision-making, policy formulation, and strategic investment in TVET. Therefore, this study seeks to address this gap by examining the level of integration of Green TVET and AI, their influence on sustainable development outcomes, and the barriers to their effective implementation in Ogun State technical colleges.

The Purpose of the Study

The purpose of this study is to assess the impact of the integration of Green Technical and Vocational Education and Training (TVET) and Artificial Intelligence (AI) on sustainable development outcomes in Ogun State technical colleges. The specific objectives are to:

i. assess the extent of integration of green TVET practices in technical colleges in Ogun State;
ii. examine the influence of AI adoption on sustainability-related outcomes, such as environmental awareness, resource efficiency, and employability of students; and
iii. identify the major barriers and enabling factors affecting the effective implementation of green TVET and AI innovations in technical colleges.

Research Questions

i. What is the extent of integration of green TVET practices in technical colleges in Ogun State?
ii. What is the influence of AI adoption on sustainability-related outcomes?
iii. What are the major barriers and enabling factors affecting the effective implementation of green TVET and AI innovations in technical colleges?

Research Hypotheses

$H_0$1: There is no significant relationship between the adoption of green TVET practices and sustainable development outcomes in Ogun State technical colleges.

$H_0$2: The use of Artificial Intelligence in technical colleges does not significantly influence students' environmental awareness.

$H_0$3: There is no significant different between major barriers and enabling factors affecting the effective implementation of green TVET and AI innovations in technical colleges

Literature Review

The education system in the world is changing and adapting to cope with the environmental problems, digital revolution, and the realization that there must be inclusive sustainable growth. The role of Green Technical and Vocational Education and Training (TVET) and Artificial Intelligence (AI) in the modernization of the education and guaranteeing its actuality in the world unstable is widely discussed. The given review takes advantage of the available body of empirical and theoretical research to investigate the existing knowledge base of green TVET, AI in education, and their combination in relation to sustainable development.

Green TVET is the integration of green principles and practices to vocational and technical training. UNESCO-UNEVOC (2021) reveals that Green TVET teaches learners the skills needed to serve the industries that cause the least amount of environmental damage, such as renewable energy, sustainable agriculture, waste management, and sustainable construction. According to Okolie, Igwe, Nwosu, Eneje and Mlanga (2019), integration of sustainability competencies on TVET not only enhances environmental literacy but also leads into green employability of graduates. Nonetheless, application in most African nations such as Nigeria has been irregular pertaining to inadequate resources,

institutional capacity, and lack of considerable policy platforms (Okhirebhu, Johnson, Oluwasola & Agboola, 2025).

Technologies of artificial intelligence are transforming the field of education in terms of instructive delivery and the management of the institution. Intelligent tutoring systems, machine-based assessment, and learning analytics in real-time are applications that allow individualized teaching and learning and inform decision making. AI can also be used to conduct practice training in technical education, but through virtual simulations, making it supplement physical infrastructure (Chen et al., 2021). Nevertheless, the research conducted in sub-Saharan Africa indicates that there are still some barriers, such as inadequate digital infrastructure, teacher capacity shortage, and cost limitations that would prevent the large-scale adoption of AI in TVET (Nwachukwu & Nnaji, 2023).

The intersection of Green TVET and AI proposes an unusual chance to provide effective, well-sustained, and progressive teaching. In the efforts of making TVET green, AI can be used to monitor energy and waste output in schools in real time, assist in online education that delivers green-sustainable oriented curricula, and track the progress of learners in creating green competencies (OECD, 2023). Empirical studies on this synergy are understudied especially in African countries, many initiatives are still in their initial or pilot stages. Evidence-based research is highly essential, to evaluate collaborative impact of these innovations toward sustainable results, including environmental awareness, process efficiency, and green job preparedness.

In Nigeria, research activity related to greening of the technical education has experienced encouraging albeit slight advancement. Adekunle and Olaleye (2022) discovered that the imposition of climate-resilient modules in technical colleges curriculum contributed to a better ecological literacy level among learners. Nonetheless, AI-related innovations are hardly applied in other spheres than computer science or ICT-related subjects. A report by the World Bank (2022) also emphasized that government agency planning must allow the growth of international development partners, as well as the stakeholders in the private sector to work together in order to have a green and digital TVET transition. There is a low adoption rate of digital tools and green initiatives in Nigeria, which is usually associated with the issue of funding, the low policy priority, and unstable curriculum change.

Although global literature supports the view that integration of sustainability and digital innovation within education is very desirable; it is lacking local studies evaluating the overall applicability of integrating the two systems and their effect. Due to industrial nature and environmental issues within Ogun State, it is a good environment to explore the possibilities of how green TVET and AI may be implemented practically in the technical colleges. Localized evidence must be created on such points as the extent of adoption, the success rate of such integration, and barriers in institution that must be overcome. The proposed study aims to close that gap in empirical evidence and become useful in local policymaking, as well as the academic debate.

Research Methodology

The research study uses the descriptive survey research design to examine how Green Technical and Vocational Education and Training (TVET) and Artificial Intelligence (AI) can integrate to achieve sustainable development results among technical colleges in Ogun State, Nigeria. The study will give an empirical account of the level of adoption and the correlation between green innovations, Artificial Intelligence use, and sustainability influence in technical education-based environments.

The target population is the teacher, administrators, senior student level in any public technical colleges who directly participate in implementation of curriculum, pedagogical development and environmental operations. A multi-stage sampling method will be used to make the sampling fair in all the senatorial districts in the State of Ogun; Ogun Central, Ogun East and Ogun West. Out of the senatorial district, a technical college will be purposely selected, depending on ease of access and involvement in environmental and technological activities. The study will use four institutions and these are; Government Technical College, Aiyetoro; Government Technical College, Idi-Aba (Abeokuta); Government Technical College, Ijebu Igbo; and Government Technical College, Ijebu-Ode. In these colleges, a stratified random sample will be employed in allocating samples to attract the administrators, teaching staff, and students in small proportions. The sample size for this study is 300 from technical colleges in Ogun state where information was generated for the results.

The data will be collected with the help of questionnaires created specifically by the researcher, named "Green TVET and AI Integration Assessment Questionnaire (GTAIAQ)". The instrument will comprise four parts that will target demographic characteristics of the respondents, the degree of implementation of green TVET, the degree of integration of AI, and perceived sustainability outcomes. The items in the questionnaire will be scored on a 5-point Likert scale assuming the responses in the form of Strongly Disagree (1), Strongly Agree (5), and a fine detail of responses in between. The questionnaire will be reviewed by content and face validity experts to guarantee that the instrument is of quality. To create reliability, pilot study will also be carried out involving respondent of non-participating college and internal reliability of the instrument will also be ascertained on Cronbach Alpha basis where a reliability coefficient of 0.70 or above is accepted.

SPSS software will be used to analyze the data that will be obtained. The research questions will be answered using descriptive statistics, that is, the means of the standard deviations, and frequency distributions. The formulated hypotheses will be tested using inferential statistics at 0.05 significance level align with Pearson correlation coefficient and independent samples t-tests. The use of both descriptive and inferential tools will help the study not only to describe the present trends but also to draw relations among green TVET, integration of AI, and its results. This methodological design guarantees the statistical strength of the study finding as well as the practical implication towards the promotion of green and technology-based learning in the technical and vocational institutions in Nigeria.

Results and Discussion

This chapter presented the analysis, interpretation of results and discussion of the findings accordingly.

The extent of integration of green TVET practices in technical colleges in Ogun State

Table 1: Respondents' Perception of Green TVET Practices

Green Practice Indicator	Mean	Std. Deviation	Interpretation
Environmental sustainability in curriculum	4.10	0.82	High
Use of eco-friendly instructional materials	3.69	0.91	Moderate
Emphasis on waste recycling and management	3.88	0.85	High
Encouragement of green entrepreneurship	3.95	0.78	High
Training in renewable energy systems	3.72	0.87	Moderate

Source: Authors' Survey, 2026

The results on Table 1 show that the perception about green TVET integration in technical colleges of Ogun State is rather positive. Based on the mean values that lie between 3.69 and 4.10 in a 5 points Likert scale, it is clear that not only is the concept of green practices recognized but that it is currently being actively implemented in the surveyed institutions on the moderate to high chance level.

The greatest mean score (M = 4.10) was measured in the indicator: Environmental sustainability in curriculum where it can be noted that there is a conscious approach to impart the concepts of sustainability in the main educational activities. This observation explains a high degree of institutional interest in creating awareness of the environmental matters and developing students with the appropriate knowledge that resonates with sustainable development goals (SDGs) principles globally, especially SDG 4 (Quality Education), and SDG 13 (Climate Action).

Another factor that lends more credence to the fact that students are being geared towards self-reliant and sustainability-based career choices is green entrepreneurship, which scored highly in terms of the mean score (M = 3.95). This plays a pivotal role in curbing youth employment in the state through introducing green ideas to the business, sustainable agriculture, wealth-to-waste, and other environment-friendly ventures. The same with waste recycling and management practices, which were

also rated high (M = 3.88) indicating that the concept of environmental learning is being used in day-to-day technical training practices.

Nevertheless, the results indicate an intermediate degree of implementation in two issues such as the use of ecological teaching materials (M = 3.69) and preparation in renewable power sources (M = 3.72). All these rather low scores point to the fact that there still might be underfinancing or logistical barriers to the provision of sustainable learning materials and practical technical training in clean energy systems even though the ideological aspects of green education might be prioritised. This disparity shows the upsurge of additional investment in more specific laboratory equipment, solar training kits, digital aids and training of trainers to offer hands-on teaching on energy-efficient technologies.

The extent of AI adoption in technical colleges

Table 2: Mean Ratings of AI Adoption

AI Feature	Mean	Std. Deviation
Personalized learning software	3.62	0.88
Use of AI-based assessments and feedback	3.55	0.94
Deployment of intelligent tutoring systems	3.49	0.90
Staff training in AI tools	3.44	0.86
Use of virtual/augmented reality tools	3.38	0.89

Source: Authors' Survey, 2026

Table 2 results show that the general use of Artificial Intelligence (AI) tools in technical colleges within Ogun State is medium. This implies that the use of AI in teaching and learning is in the period of introduction to this area of instruction and not fully mainstream in all aspects in teaching and learning.

Customized learning software obtained the highest mean score (M = 3.62), which means that adaptive learning environments, or more specifically AI-driven learning management systems and algorithm-based educational applications, are on the rise. These aids assist in differentiating instructions to suit students at their own levels, pace and rates hence facilitating efficiency and enhanced learning towards material. The result is in line with the current world trends stressing individualization as one of the significant advantages of AI in education.

Coming right behind are AI-affiliated evaluation and feedback systems (M = 3.55), which are an indication that the institutions are employing AI to automate assessment, offer instant feedback and monitoring of performance. On top of offloading teacher workload, these practices would help come up with actionable results that would be used in early identification. Nonetheless, despite their value, the comparatively moderate average presupposes that the systems are not popular yet, which can be caused by the lack of necessary infrastructure or training.

Systems of intelligent tutoring (M = 3.49) and AI tools training (M = 3.44) within the staff also showed moderate ratings. Intelligent tutoring which includes the use of AI platforms that mimic one-on-one instruction is the future and it seems to be being underutilized, maybe because of the lack of technical availability and finance. Staff training, one more important aspect of sustainable AI integration, received a modestly good score as well. This is an indication of a capacity building gap; instructors might not be able to successfully incorporate and sustain AI tools in the classrooms without undergoing consistent professional development.

Attitudes towards the use of virtual and augmented reality (VR/AR) tools were the lowest (M = 3.38) and correspond to the low-moderate range. There seems to be a limited usage of immersive technologies in spite of their potential to transform experiential learning, particularly in technical, and vocational learning. It can be explained by either the high price of VR/AR infrastructure, the absence of locally produced content or inadequate training on the ways to use such devices in teaching their subjects.

Although the technical colleges in Ogun State have taken preliminary steps in the practice of AI, especially in customized learning and automated evaluation, the complete incorporation of the same is still constrained by competence gaps, lack of infrastructure and poor utilisation of innovative immersive technologies. Increasing staff capacity, access to digital infrastructure, and finding AI

applications to be applied in a given context may thus go a long way in boosting the use and effectiveness of AI in such institutions.

The influence of green TVET practices and AI integration on students' environmental awareness and employability in Ogun State technical colleges

Table 3: Perception of Students on the Influence of Green TVET and AI on Awareness and Employability

Indicator	Mean	Std. Dev
TVET curriculum improves understanding of environmental issues	4.21	0.69
AI tools enhance environmental problem-solving skills	3.97	0.82
Exposure to green practices motivates sustainable lifestyle choices	4.09	0.76
AI improves access to career-relevant knowledge and skills	3.88	0.85
Green TVET and AI together improve employability in green job sectors	4.15	0.73

Source: Authors' Survey, 2026

The findings displayed in Table 5 show that the respondents think that the impact of green TVET and AI on their environmental understanding and employment potential is very high. The indicator with the highest rating, which is, "TVET curriculum enhances the awareness of environmental matters" (Mean = 4.21), implies that green TVET programs are working to inculcate sustainability awareness on learners.

Equally, students have admitted that AI can play an important role in the formation of their sustainability problem-solving skills (Mean = 3.97). This means that there is a trend in environmental literacy and decision-making by means of smart systems through the use of simulation software, virtual labs, and adaptive learning systems.

Further, the almost medium score of the statement: Green TVET and AI combined enhance employability in the realm of green jobs (Mean = 4.15) supports the presumption that the introduction of AI in TVET process does not only contribute to academic progress but does not make learners gain more chances to be competitive in green job areas such as renewable energy, environmental control, and smart production.

Interpretation establishes that once green technical training is integrated with AI innovations, the students would be more aware of the environment and would have the competencies needed in the job world related to the goals of sustainable development. The conclusion of the finding advocates policy investments in the two sectors as a strategic route towards youth empowerment and environmental stewardship.

Hypothesis Testing

Hypothesis 1: To determine the relationship between green TVET practices and sustainable development outcomes

Table 4: Pearson Correlation

Variable 1	Variable 2	Pearson r	Sig. (2-tailed)	Interpretation
Green TVET Practices	Sustainability Outcomes	0.614	0.000	Strong Positive Correlation

Source: Authors' Survey, 2026

The Pearson product-moment correlation, which was obtained and compiled in Table 4, shows that there exists a positive relationship between green TVET practices and sustainability results that is strong and statistically significant ($r = 0.614$, $p < 0.01$). This implies that the higher the rate of integration of green practices in technical and vocational education and training (TVET), the better are the outcomes of students concerning sustainability.

The value of the correlation (r = 0.614) is above the moderate level (0.3 to 0.5) and reaches the high factor (0.61 to 0.99), which indicates a strong connection between two variables. The significance level (p=0.000) further proves the relationship is not occurred by chance and this relationship is significant at 1% level (p<0.01). The conclusion of this statistical result supports hypothesis 1 which stated that there was indeed a significant relationship between adoption of green TVET practices and the connection to sustainability outcomes in the technical colleges.

Practically, this implies that the more institutions have practices with the knowledge they want to inculcate in the students that relate to environment such as sustainable curriculum creation, safe use of materials, recycling programs and renewable energy education, the greater are the chances of producing learners that show their awareness of the environment, accountability to the sustainable development, and preparation to work in green jobs. Such results are essential in equipping the workforce with the requirements of low-carbon and climate-resistant economy.

This result concurs with the already available empirical literature. Take Mutebi and Kiplagat (2022), which highlights the importance of green TVET as a way to provide the competencies needed by young people in helping achieve a sustainable development. On the same note, it is the view of Abo-Khalil (2024) that the inclusion of sustainability in technical education provides learners with the ability to innovate the environmentally friendly way.

Hypothesis 2: Influence of AI Use on Student Awareness and Employability

Table 5: Independent Samples T-Test

Group	N	Mean	Std. Deviation	T	Df	Sig. (2-tailed)
High AI Use	100	4.18	0.76	4.517	198	0.000
Low AI Use	100	3.74	0.82	—	—	—

Source: Authors' Survey, 2025

The t-test gives a statistically significant difference between students exposed to high level of exposure concerning Artificial Intelligence tools and those exposed to low level with regard to environmental awareness and employability of the students. The average score of the students in the High AI Use group of students was 4.18 whereas that of Low AI Use group of students was 3.74. This suggests that the greater awareness of environmental sustainability and readiness to find a job especially in the green and the technologies-centered segment is more likely to be found in the students who are the more frequent users of AI-based educational devices (in the form of virtual simulations, intelligent tutoring systems, or adaptive e-learning environments).

The t statistic of 4.517 and a p statistic of 0.000 (which is less than the significance level of 0.05) will cause a rejection of the null hypothesis. It means that the difference observed is not just a chance but a real effect that proves the statement about the great contribution of AI integration to the preparedness of students to work in the career area oriented on sustainability challenges and the readiness to perceive and solve environment-related issues.

This piece of information is in line with past studies, including the one by Alimisis (2021), who stated that TVET classrooms with the help of AI allow to engage in deeper learning and assist students in bridging the theoretical and practical divide regarding green competencies. In a similar fashion, Okoye, Campos, Das, Chakraborty, Ghosh, Chakrabarti, & Hosseini (2025) acknowledged digital tools, especially AI-based ones, the role in the creation of SDG-related positive learning outcomes.

Conclusion and recommendations

This study has demonstrated that the integration of Green Technical and Vocational Education and Training (TVET) and Artificial Intelligence (AI) in Ogun State technical colleges has a positive impact on sustainable development outcomes. The study therefore recommends that:

i. Regular capacity-building workshops should be organized to equip educators with skills in green TVET practices and the effective use of AI tools.
ii. Technical colleges should be better equipped with eco-friendly facilities and AI-based learning technologies to support practical and innovative teaching.
iii. The TVET curriculum should be updated to integrate green education and AI competencies aligned with sustainable development goals.

iv. Government agencies should develop supportive policies and allocate funding to encourage sustainable and tech-driven educational practices in technical colleges.

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