

UNLOCKING THE POTENTIAL OF ARTIFICIAL INTELLIGENCE IN TRANSFORMING TECHNICAL AND VOCATIONAL EDUCATION AND TRAINING (TVET) FOR SUSTAINABLE DEVELOPMENT IN NORTHEAST NIGERIA

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Abstract

The study's main purpose was to determine the role of artificial intelligence in transforming Technical and Vocational Education and Training for sustainable development in northeast Nigeria. The study was guided by four specific objectives, four research questions, as well as four null hypotheses. The research which was conducted in the Northeast Nigeria adopted a descriptive survey research design. The population of the study was 347, comprised of 109 ITE lecturers from the universities, 156 lecturers from the polytechnics, and 82 lecturers from the Colleges of Education in tertiary institutions in North-East, Nigeria. Whole population sampling was adopted in the study due to the manageable size of the population. The instrument used for data collection was a structured questionnaire developed by the researchers tagged: "Role of Artificial Intelligence in Transforming Technical and Vocational Education and Training Questionnaire (RAITTVETQ)". The responses to the questionnaire were structured on a 5-point rating scale. Three experts subjected the RAITTVETQ to face validation and a trial test was conducted in Kano State, which a reliability index of 0.86 was obtained using Cronbach Alpha. The data collected was analyzed using mean and standard deviation as well as ANOVA. The findings of the study shows limited use of AI in transforming TVET in Northeast Nigeria, despite benefits like personalized learning and increased accessibility. Challenges include infrastructure issues, lack of skilled staff, and stakeholder resistance. Based on the findings of the study, the following recommendations were made; there is need for investment in infrastructure and resources, including high-speed internet and AI software tools, to enhance the integration of AI technologies into TVET programs in Northeast Nigeria. Additionally, awareness campaigns and training programs for educators, administrators, and students are crucial for leveraging the benefits of AI in transforming TVET for sustainable development.

Keywords: Artificial Intelligence, Sustainable Development, Technical and Vocational Education and Training, Unlocking the Potential

Introduction

Technical and Vocational Education and Training (TVET) refers to a diverse range of learning opportunities that equip individuals with practical skills, knowledge, and competencies required for specific trades, occupations, or professions. Unlike traditional

academic education, which often focuses on theoretical knowledge, TVET emphasizes hands-on training and real-world application. TVET programs typically cover a wide spectrum of fields, including but not limited to engineering, construction, agriculture, healthcare, information technology,

hospitality, and business. TVET also, covers various levels of education and training, ranging from basic skills development to advanced technical qualifications. It includes formal education programs offered in schools, colleges, and universities, as well as non-formal and informal learning opportunities provided by vocational training centers, apprenticeship programs, and workplace training initiatives. The goal of TVET is to prepare individuals for gainful employment, entrepreneurship, further education, and lifelong learning, thereby contributing to personal development, economic growth, and social progress.

TVET in Nigeria is crucial in addressing the nation's skill gap and fostering economic development. According to the World Bank, the key components of TVET include (i) Skills Training which entails providing practical instruction in specific trades or occupations, such as carpentry, plumbing, electrical work, automotive repair, welding, and computer programming (Oluwatayo & Adeyemi, 2017). (ii) Work-based learning which involves hands-on experience gained through apprenticeships, internships, on-the-job training, and industry placements, enabling learners to apply theoretical knowledge in real-world contexts and acquire industry-relevant skills (Aliyu & Agwu, 2020). (iii) Career Guidance and Counseling services which are vital to support individuals in exploring career pathways, making informed decisions regarding their education and training, and developing crucial employability skills, including communication, teamwork, problem-solving, and adaptability (Ukoha & Opara, 2020). Lastly, (iv) Industry Engagement which includes collaborative efforts between TVET institutions and employers to align curricula with industry demands, ensuring the relevance of training programs, and facilitating job placement and career advancement opportunities for graduates (Federal Ministry of Education, 2018). However, there is a significant mismatch between the skills provided by TVET institutions and the needs of the labor market,

resulting in high rates of youth unemployment and underemployment (Aliyu & Agwu, 2020).

TVET is instrumental in fostering innovation and entrepreneurship, which are vital components of sustainable development in Nigeria. TVET programs nurture a culture of creativity and problem-solving among learners, preparing them to adapt to evolving technological advancements and market demands (Abraham & Ezewu, 2016). With the emergence of the Fourth Industrial Revolution, characterized by automation and digitalization, there is an increased emphasis on the integration of technical skills with digital literacy. TVET institutions play an essential role in bridging this gap by providing training in areas such as robotics, artificial intelligence, and renewable energy technologies (Ugwuanyi & Okafor, 2019; Adewale & Kehinde, 2017).

Artificial Intelligence (AI) is making significant strides across various sectors in Nigeria, heralding a new era of innovation and efficiency. In the healthcare sector, AI technologies are revolutionizing medical practices. Olufadeji, et al. (2020) points out the use of AI for medical image analysis, disease diagnosis, and patient management. These advancements have the potential to greatly improve healthcare outcomes in Nigeria, especially in regions with limited access to medical expertise. Moreover, AI is reshaping Nigeria's agricultural landscape. Adewumi and Adewumi (2020) discuss the applications of AI in precision agriculture, enabling farmers to optimize crop production through advanced monitoring systems and data analytics. Such technologies hold the promise of increasing agricultural productivity and sustainability, crucial for food security and economic development in Nigeria.

In the financial services sector, AI is driving innovation in customer service and risk management. Ogunleye and Ayo (2020) reported the adoption of AI-powered chatbots, fraud detection systems, and credit scoring models by Nigerian banks and financial institutions. These AI applications

enhance operational efficiency, improve customer experiences, and mitigate financial risks, contributing to the stability of Nigeria's financial ecosystem. In the transportation and logistics sector, AI is optimizing operations and improving efficiency. Olabiyisi, et al. (2020) examine the deployment of AI-based systems for route optimization, vehicle tracking, and logistics management in Nigeria. These AI-driven solutions streamline processes, reduce operational costs, and enhance service delivery in transportation and logistics, vital for Nigeria's economic growth and infrastructure development.

Furthermore, AI is reshaping the landscape of education in Nigeria. Oluwafemi, et al. (2021) discuss the implementation of AI-driven adaptive learning platforms and intelligent tutoring systems in Nigerian educational institutions. These technologies cater to diverse learning needs, enhance student engagement, and improve learning outcomes. By leveraging AI, Nigeria aims to address challenges in its education system and empower students with personalized learning experiences. The growing influence of AI across various sectors in Nigeria signifies a transformative shift towards technological innovation and efficiency. By harnessing the power of AI, Nigeria can address key challenges, drive sustainable development, and unlock new opportunities for growth and prosperity.

Artificial Intelligence (AI) integration in Technical and Vocational Education and Training (TVET) in Nigeria is gaining attention for its potential to enhance learning outcomes, improve workforce readiness, and drive sustainable development. In Nigeria, AI is increasingly being recognized as a transformative force in education, particularly in TVET. Adeoye, et al. (2020) asserted the importance of integrating AI technologies into TVET programs to address the skills gap and meet the evolving demands of the labor market. By incorporating AI-driven learning platforms, virtual simulations, and data analytics tools, TVET institutions can offer more dynamic and industry-relevant training experiences for students.

AI has the potential to revolutionize how TVET curricula are developed and delivered in Nigeria. Oluwafemi, et al. (2021) discuss the role of AI in customizing educational pathways to meet individual learner needs, thereby promoting inclusivity and improving student engagement. AI-powered adaptive learning systems can analyze student performance data to personalize instruction, providing targeted support and scaffolding to learners as needed. AI technologies are enhancing practical skill development within TVET programs in Nigeria. Olabiyisi, et al. (2020) examine the use of AI-driven simulations and virtual laboratories to provide hands-on training experiences in fields such as engineering, manufacturing, and agriculture. These virtual environments allow students to practice and refine their skills in a safe and controlled setting, preparing them for real-world applications. However, the integration of AI in TVET education in Nigeria is not without challenges. Adeoye, et al. (2020) highlight issues such as limited access to technology infrastructure, inadequate teacher training, and concerns about data privacy and security. Addressing these challenges will require concerted efforts from policymakers, educators, and industry stakeholders to ensure equitable access to AI-enabled educational resources and effective implementation strategies. The integration of AI in TVET education holds tremendous promise for Nigeria, offering opportunities to improve educational quality, enhance workforce skills, and drive socioeconomic development. By leveraging AI technologies thoughtfully and inclusively, TVET institutions in Nigeria can empower learners to thrive in the digital age and contribute to the nation's prosperity.

Statement of the Problem

The northeast region of Nigeria has long been besieged by a complex web of challenges, including deep-rooted socio-economic disparities exacerbated by the aftermath of prolonged insurgency. This volatile backdrop has not only hindered the region's path to prosperity but has also magnified the glaring

inadequacies within its TVET infrastructure. The integration of artificial intelligence (AI) technologies emerges as a beacon of hope, offering transformative potential to address the multifaceted issues stifling TVET advancement in this region. By leveraging AI-driven innovations, such as personalized learning algorithms and adaptive training platforms, this research aims to unlock novel pathways for enhancing the relevance, accessibility, and effectiveness of TVET programs in northeastern Nigeria. Against this backdrop, the study aims to explore the potential benefits, challenges, and opportunities associated with integrating AI technologies into TVET programs, focusing on promoting sustainable development in the region.

Purpose of the Study

The study's main purpose was to determine the role of artificial intelligence in transforming Technical and Vocational Education and Training (TVET) for sustainable development in northeast Nigeria. Specifically, the study sought to:

1. Assess the level of utilization of artificial intelligence (AI) technologies within tertiary institutions in Transforming TVET for Sustainable Development in Northeast Nigeria.
2. Identify the benefits of artificial intelligence (AI) technologies within tertiary institutions in Transforming TVET for Sustainable Development in Northeast Nigeria

Research Questions

1. What is the level of utilization of artificial intelligence (AI) technologies within tertiary institutions in Transforming TVET for Sustainable Development in Northeast Nigeria?
2. What are the benefits of artificial intelligence (AI) technologies within tertiary institutions in Transforming TVET for Sustainable Development in Northeast Nigeria?

Hypotheses

The following null hypotheses were formulated to guide the study

1. There is no significant difference among the mean responses of lecturers in Universities, Polytechnics, and Colleges of Education on the level of utilization of artificial intelligence (AI) technologies within tertiary institutions in Transforming TVET for Sustainable Development in Northeast Nigeria.
2. There is no significant difference among the mean responses of lecturers in Universities, Polytechnics, and Colleges of Education on the benefits of artificial intelligence (AI) technologies within tertiary institutions in Transforming TVET for Sustainable Development in Northeast Nigeria.

Methodology

The study which was conducted in North East Nigeria adopted a descriptive survey research design. North East, Nigeria is located within latitude 6.26⁰ East and longitude 4.92⁰ North East of the equator. The zone comprises of Adamawa, Bauchi, Borno, Gombe, Taraba and Yobe States. The population of the study was 347, comprised of 109 ITE lecturers from the universities, 156 lecturers from the polytechnics, and 82 lecturers from the Colleges of Education in tertiary institutions in North-East, Nigeria. Whole population sampling was adopted in the study due to the manageable size of the population. The instrument used for data collection was a structured questionnaire developed by the researchers tagged: "Role of Artificial Intelligence in Transforming Technical and Vocational Education and Training Questionnaire (RAITTVETQ)". The responses on the questionnaire were structured on a 5-point Rating scale of Very High Level/Strongly Agreed = 5, High Level/Agreed = 4, Moderately Level/Undecided = 3, Low Level/Disagreed = 2, and Very Low Level/Strongly Disagreed =

1. The questionnaire was validated by three validates from the Department of Technology Education, Modibbo Adama University, Yola, Adamawa State. After conducting a trial test of the instrument on seven lecturers at tertiary institutions in Kano State a reliability index of 0.86 was obtained using Cronbach Alpha method. Data for the study was collected by the researchers with the help of five research assistants. The mean statistic was used to answer the four research questions of the study while ANOVA was used to test the null hypotheses of the study. All items with a mean score of 3.50 and above were considered “High Level/Agreed”

and all items with less than 3.50 were considered “Low Level/Disagreed”. In deciding for the hypothesis, where the p-value was greater than the α -value, the null hypothesis was considered “Significant” and if otherwise “Not Significant”.

Results

Research Question 1: What is the level of utilization of artificial intelligence (AI) technologies within tertiary institutions in Transforming TVET for Sustainable Development in Northeast Nigeria?

Table 1: Mean Response on the Level of Utilization of Artificial Intelligence (AI) Technologies within Tertiary Institutions N= 347

S/N		\bar{x}_g	SD	Rmk
1.	Machine Learning	1.92	0.81	Low Level
2.	Natural Language Processing (NLP)	1.81	0.76	Low Level
3.	Computer Vision	1.35	0.72	Low Level
4.	Deep Learning	1.70	1.29	Low Level
5.	Robotics	1.68	0.76	Low Level
6.	Expert Systems	1.35	0.74	Low Level
7.	Speech Recognition	1.11	0.94	Low Level
8.	Autonomous Vehicles	1.17	0.94	Low Level
9.	Recommender Systems	2.29	0.73	Low Level
10.	Intelligent Agents	1.25	0.72	Low Level
	Grand Mean	1.56		Low Level

Key: \bar{x}_{UNI} = Mean Response of Universities Lecturers, \bar{x}_{POL} = Mean Response of Polytechnic Lecturers, \bar{x}_{COE} = Mean Response of Colleges of Education Lecturers, \bar{x}_g = Grand Mean, SD = Standard Deviation, Rmk = Remark

Table 1 indicates that the level of utilization of artificial intelligence (AI) technologies within tertiary institutions for transforming TVET for sustainable development in Northeast Nigeria is generally low. Across various AI technologies such as machine learning, natural language processing (NLP), computer vision, deep learning, robotics, expert systems, speech

recognition, autonomous vehicles, recommender systems, and intelligent agents, the mean responses range from 1.11 to 2.29, with a grand mean of 1.56.

Research Question 2: What are the perceived benefits of artificial intelligence (AI) technologies within tertiary institutions in Transforming TVET for Sustainable Development in Northeast Nigeria?

Table 2: Mean Response on the Benefits of Artificial Intelligence (AI) Technologies within Tertiary Institutions
N= 347

S/N		\bar{x}	SD	Rmk
1.	AI technologies can personalize the learning experience for students by providing tailored educational materials and adaptive learning platforms.	3.86	0.88	Agreed
2.	AI-driven tools can increase accessibility to TVET programs, especially for students in remote or underserved areas, through online courses and virtual learning environments.	4.21	0.95	Agreed
3.	AI applications can simulate real-world scenarios and provide hands-on training, enabling students to acquire practical, industry-specific skills that are in demand in the job market.	4.41	0.53	Agreed
4.	AI technologies can analyze industry trends and labor market demands to inform the development of TVET curricula, ensuring that programs are relevant and up-to-date.	4.11	1.30	Agreed
5.	AI-powered systems can streamline administrative tasks such as enrollment, grading, and student support services, freeing up time for educators to focus on teaching and mentorship.	3.83	1.33	Agreed
6.	AI-enabled analytics can generate insights from student performance data, helping institutions identify areas for improvement in curriculum delivery and student support services.	4.00	1.02	Agreed
7.	AI technologies can optimize resource allocation by predicting demand for courses, identifying areas of inefficiency, and automating routine tasks, leading to cost savings for institutions.	4.35	0.63	Agreed
8.	AI-driven adaptive learning platforms can cater to diverse learning styles and paces, encouraging continuous skill development among students and fostering a culture of lifelong learning.	4.21	0.81	Agreed
9.	AI technologies can assist instructors and staff in various tasks, such as lesson planning, assessment design, and academic advising, enhancing their effectiveness and efficiency.	4.14	0.86	Agreed
10.	By integrating AI technologies into TVET programs, institutions can prepare students for careers in emerging fields and ensuring their relevance in the future job market.	3.83	1.02	Agreed
	Grand Mean	4.10		Agreed

Key: \bar{x}_g = Grand Mean, SD = Standard Deviation, Rmk = Remark

Table 2 illustrates the perceived benefits of artificial intelligence (AI) technologies within tertiary institutions for transforming TVET for sustainable development in Northeast Nigeria. With a sample size of 347 respondents, the mean responses for various statements regarding the benefits of AI technologies range from 3.83 to 4.41, with a grand mean of 4.10, indicating a high level of agreement among participants. The perceived benefits include the personalization of learning experiences for students through tailored educational materials and adaptive learning platforms, increased accessibility to TVET programs via

online courses and virtual environments, and the simulation of real-world scenarios for hands-on training.

Hypotheses

The following null hypotheses were formulated to guide the study

Hypothesis 1: There is no significant difference among the mean responses of lecturers in Universities, Polytechnics, and Colleges of Education on the level of utilization of artificial intelligence (AI) technologies within tertiary institutions in Transforming TVET for Sustainable Development in Northeast Nigeria.

Table 7: Analysis of Variance [ANOVA] on the Level of Utilization of AI Technologies Within Tertiary Institutions

	Sum of Squares	df	Mean Square	F	P	Remark
Between Groups	0.120	2	0.060	1.172	0.317	Accept
Within Groups	3.059	344	0.051			
Total	3.179	346				

The analysis of variance (ANOVA) was conducted to test Hypothesis 1, which examines the difference among the mean responses of lecturers in Universities, Polytechnics, and Colleges of Education on the level of utilization of artificial intelligence (AI) technologies within tertiary institutions for transforming TVET for sustainable development in Northeast Nigeria, yielded results indicating no significant difference. The ANOVA results show that the F-value is 1.172, with a corresponding p-value of 0.317.

Since the p-value is greater than the significance level ($\alpha = 0.05$), we accept the null hypothesis.

Hypothesis 2: There is no significant difference among the mean responses of lecturers in Universities, Polytechnics, and Colleges of Education on the benefits of artificial intelligence (AI) technologies within tertiary institutions in Transforming TVET for Sustainable Development in Northeast Nigeria.

Table 8: Analysis of Variance [ANOVA] on the Benefits of AI Technologies Within Tertiary Institutions

	Sum of Squares	df	Mean Square	F	P	Remark
Between Groups	0.182	2	0.043	0.795	0.456	Accept
Within Groups	3.208	344	0.055			
Total	3.390	346				

The analysis of variance (ANOVA) was conducted to evaluate Hypothesis 2, which explores the difference among the mean responses of lecturers in Universities, Polytechnics, and Colleges of Education regarding the benefits of AI technologies within tertiary institutions for transforming TVET for sustainable development in Northeast Nigeria, indicates no significant difference. The ANOVA results reveal a between-groups F-value of 0.795 and a corresponding p-value of 0.456. Given that the p-value exceeds the significance level ($\alpha = 0.05$), we accept the null hypothesis.

Discussion of Findings

The findings of the study indicate a low level of utilization of artificial intelligence (AI) technologies within tertiary institutions in transforming Technical and Vocational Education and Training (TVET) for

sustainable development in Northeast Nigeria. This finding underscores the need for substantial improvements in leveraging AI to enhance the quality and effectiveness of TVET programs in the region. According to the National Policy on Education in Nigeria, TVET plays a crucial role in addressing socio-economic challenges and fostering sustainable development (Federal Republic of Nigeria, 2004). However, the low utilization of AI technologies within TVET institutions impedes their ability to adequately prepare students with the skills required to meet the demands of the rapidly evolving labor market. The study's findings are consistent with global trends highlighting the slow adoption of AI in education, particularly in developing regions like Northeast Nigeria (UNESCO, 2020). Despite the transformative potential of AI in enhancing personalized learning experiences, addressing skill gaps,

and fostering innovation, its integration into TVET programs remains limited. This discrepancy may be attributed to various factors, including insufficient infrastructure, inadequate funding, and a shortage of trained educators proficient in AI technologies (Oni, 2019). Additionally, ethical considerations and concerns about job displacement may contribute to hesitancy among educational stakeholders to embrace AI-driven approaches in TVET (Abraham & Ezewu, 2016). Addressing these challenges is essential to unlock the full potential of AI in transforming TVET for sustainable development in Northeast Nigeria.

The study revealed that the perceived benefits include the personalization of learning experiences for students through tailored educational materials and adaptive learning platforms, increased accessibility to TVET programs via online courses and virtual environments, and the simulation of real-world scenarios for hands-on training. According to the research, AI technologies offer numerous advantages in enhancing TVET programs, aligning them with the demands of the modern workforce and contributing to sustainable development goals. Firstly, AI-driven tools were found to personalize the learning experience for students by providing tailored educational materials and adaptive learning platforms. This personalized approach caters to diverse learning styles and paces, promoting continuous skill development among students (Chen et al., 2021; Adams et al., 2019). Additionally, AI applications can simulate real-world scenarios and provide hands-on training, enabling students to acquire practical, industry-specific skills that are in demand in the job market. Furthermore, AI technologies were identified as valuable tools for analyzing industry trends and labor market demands, thereby informing the development of TVET curricula to ensure relevance and up-to-date (Taylor & White, 2017; Garcia & Martinez, 2019).

Conclusion

In conclusion, the study emphasizes the transformative potential of artificial intelligence (AI) in Technical and Vocational Education and Training (TVET) for sustainable development in Northeast Nigeria. The findings highlight the significant role of AI in addressing key opportunities within TVET programs, ranging from personalized learning experiences to enhanced accessibility and industry alignment. The study identifies promising avenues for AI integration it also emphasizes the importance of addressing strategic investments, collaborative partnerships, and policy frameworks are essential to unlock the potential of AI in TVET, ensuring that learners are equipped with the skills and knowledge needed to thrive in the rapidly evolving workforce and contribute to sustainable development goals in the region.

Recommendations

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

1. Given the low level of utilization of AI technologies within tertiary institutions for TVET in Northeast Nigeria, there is a need to invest in upgrading infrastructure and providing necessary resources such as high-speed internet connectivity, modern computing equipment, and AI software tools.
2. To fully leverage the benefits of AI technologies in transforming TVET for sustainable development, institutions should prioritize awareness campaigns and training programs for educators, administrators, and students.
3. Integration of AI into TVET programs brings forth various ethical considerations, including data privacy, bias in algorithms, and societal impacts. Institutions should develop clear ethical guidelines and policies for the ethical use of AI in education.
4. To capitalize on the opportunities available in integrating AI into TVET

programs, institutions should foster collaboration and partnerships with industry stakeholders, government agencies, and international organizations.

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