Advancing TVET Through Web 3.0 Technologies: Perceptions and Utilization Among Lecturers in Nigerian Universities

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Abstract
This study evaluated the perceptions, utilization and challenges of Technical Vocational Education and Training (TVET) lecturers regarding Web 3.0 technologies in Nigerian universities in South-South geopolitical zone. Three research questions three corresponding null hypotheses and descriptive survey research design was adopted for the study. The population comprised 128 TVET lecturers (96 Male and 32 Female), from which 105 respondents (75 Male, 30 Female) were purposively selected. Data were collected using a 30-item structured questionnaire validated by three experts and tested for reliability using Cronbach alpha, yielding an overall coefficient of .78 (.83, .74, .77 for sections B, C and D, respectively), indicating that the instrument was reliable. A five-point Likert scale was employed to measure responses. Data were analyzed using mean and standard deviation for research questions, while independent t-test was used to test hypotheses at a .05 significance level. Findings revealed that lecturers had strong positive perceptions toward Web 3.0 technologies and acknowledged the potential to enhance interactive, personalized and practical learning. However, actual utilization was moderate, hindered by inadequate infrastructure, limited access to learning resources, lack of curriculum integration, insufficient technical support, high costs, unreliable internet and limited digital skills among students. T-test analysis showed no significant gender differences in perceptions, utilization or challenges. The study recommends improving university infrastructure, ensuring stable internet connectivity, investing in AI and VR tools, revising curricula to incorporate Web 3.0, organizing regular professional development for lecturers and establishing technical support units.

Keywords: *TVET, Lecturers, Perception, Utilization, Web 3.0, Universities, Nigeria*

Introduction

Over the years, teaching and learning have largely relied on traditional methods, which are now seen as inadequate for addressing students' needs and improving outcomes (Idhalama, Krubu & Etebu, 2023). The rapid growth of Information and Communication Technologies (ICTs) has transformed higher education through tools like video conferencing, e-learning and mobile technologies, offering solutions to 21st-century challenges (Echeng & Usoro, 2014). Web-based instructional technologies have further enriched educational experiences (Idhalama, Krubu & Etebu, 2023). The "first-generation Web" or Web 1.0 followed a one-way communication model where users mainly consumed content (Makori, 2011). Web 2.0, introduced by Ohei and Brink (2019), enabled interactivity, user-generated content and collaboration. Furthermore, Ohei and Brink (2019) noted that Web 3.0,

envisioned by Markoff in 2006, brought intelligent tools supporting dynamic educational delivery, improving student engagement.

Albu (2013) defines Web 3.0 as a system where computers independently generate information. Bica, Curil and Curil (2013) see it as the initial stage of the metaverse, integrating technologies like 3D simulation, virtual reality and semantic standards. Berners-Lee, Fischetti and Dertouzos (2022) describe it as an intelligent semantic web using metadata to deliver smart responses, while Ivan (2011) refers to it as a geospatial web that indexes data by location. Common tools include blogs, wikis, RSS feeds, YouTube, Facebook, Twitter, Skype, podcasts, Google Apps and WhatsApp (Luo, 2010; Makori, 2011; Hough & Neuland, 2012). With features like AI, semantic web, blockchain and decentralized platforms, Web 3.0 is transforming teaching and research in universities (Agarwal & Kumar, 2023). Globally, institutions are adopting these tools to encourage collaborative learning across disciplines, especially in Vocational and Technical Education (VTE), Engineering and Media (UNESCO, 2023). Education plays a vital role in preserving and advancing knowledge and skills for human development and resilience (Owo, 2020).

Universities worldwide strive to provide quality education focused on teaching, research and community service (Ogbulogo, George & Olukanni, 2014). They are committed to developing human capacity through education, research and service (Oyeniran et al., 2020). Universities aim to produce competent, reliable and morally grounded graduates. Owo and Ajie (2020) further emphasize universities' responsibility in advancing human development. Lecturers are central to this mission, balancing teaching, research and community service (Owo & Ajie, 2020). Bakare, Onah and Okereke (2018) state that effective lecturers are adaptable, intelligent and committed to continuous professional development. The quality of academic delivery is influenced by teaching methods, instructor personality and the integration of technology. When lecturers are technologically competent, they can deliver lessons through diverse formats, including face-to-face, online and distance learning.

Smith and Johnson (2022) highlighted that universities in developed countries use blockchain for secure records, AI for personalized learning and immersive simulations for technical training. These innovations promote interactive learning and real-time data-driven feedback. Similarly, Echeng and Usoro (2014), Ukwu and Ukwu (2021) noted improved student engagement and performance through these technologies. Countries like China, India and South Korea have integrated AI and VR into vocational training (Brown, Chen & Williams, 2023). In developing nations like Nigeria, adoption of these technologies is still emerging (Ogunleye & Adeyemi, 2023). Since the National Policy on Education, Nigeria's higher institutions have improved offerings, including TVET programs leading to B.Sc Ed. degrees in fields such as automobile, mechanical and building technology (FRN, 2013; Owo & Deebom, 2020).

The Nigerian National Policy on Education (FRN, 2013) defines Technical Vocational Education and Training (TVET) as acquiring practical skills, knowledge and attitudes relevant to various occupations alongside general education. Traditional methods emphasize hands-on training, but the integration of AI-powered simulations, VR modules and blockchain-certified credentials could revolutionize skill development (Oladimeji & Yusuf, 2022; Eke, 2023). These technologies allow students to gain virtual practical experience before hands-on work. Integrating such tools into TVET could bridge the gap between traditional approaches and modern industry demands. Smart contracts for credential verification, AI tutors and AR/VR-based classrooms are poised to reshape technical education (Okafor & Nwafor, 2023). Web 3.0 technologies support content creation, sharing and intelligent search (Berners-Lee, Fischetti, & Dertouzos, 2022) and their application in VTE in South-South Nigeria could enhance competency-based learning (Oladimeji & Yusuf, 2022).

Idhalama, Krubu and Etebu (2023) stated that Nigerian lecturers are slow to adopt new technologies due to several challenges. Although agencies like the NUC and NBTE promote digital education, most policies still center on basic e-learning rather than emerging Web 3.0 tools (NBTE, 2023; Agarwal & Kumar, 2023). The challenges facing lecturers in the utilization of web 3.0 include limited funding, digital illiteracy, poor infrastructure and inconsistent implementation (Berners-Lee, Fischetti & Dertouzos, 2022; Smith & Johnson, 2022; Okafor & Nwafor, 2023). Lecturers' and students' digital competence significantly affects Web 3.0 adoption (Adebayo, 2023). Students are generally more receptive, but lecturers' readiness depends on their training and tech exposure (Oladimeji & Yusuf, 2022). Hough and Neuland (2012), observed that Nigerian universities lack key Web 3.0 tools like Wikis, Twitter and Blogs. Barriers such as poor infrastructure, lack of tech support and insufficient training hinder interactive learning. Luo (2010) noted that devices like e-readers, digital players and PDAs remain underutilized.

Many lecturers and students lack awareness of advanced learning technologies, leading to limited Web 3.0 use (Okafor & Nwafor, 2023). Concerns about data privacy, security and resistance to decentralized learning models further obstruct adoption (Smith & Johnson, 2022). In South-South Nigeria, unreliable internet, lack of digital labs and limited access to smart tools restrict effective use of AI systems and modern learning platforms (Ogunleye & Adeyemi, 2023). Adeyemi and Awolusi (2021) noted that lecturers' skills and attitudes play a vital role in tech adoption, while Luo (2010) emphasized Web 3.0 potential in online education. Eke (2023) recommends continuous professional development, institutional support and robust digital infrastructure for successful Web 3.0 integration. Adoption could boost employability, industry-academia collaboration and improve learning outcomes (UNESCO, 2023). However, the extent of Web 3.0 adoption among lecturers and students in Nigerian universities remains underexplored (Adebayo, 2023). This study therefore assessed how VTE lecturers and students in South-South Nigeria perceive and use Web 3.0 technologies.

Statement of the Problem

Web 3.0 in Vocational and Technical Education (VTE) supports personalized skill acquisition, blockchain credentialing and AI-powered assessments, making it essential for preparing a future-ready workforce (Berners-Lee, Fischetti, & Dertouzos, 2022). However, Nigerian TVET institutions face challenges like limited tech integration, poor infrastructure and low digital literacy among educators and students (Oluwaseun & Edewor, 2022). Barriers such as low awareness, resistance to change and institutional limitations hinder the adoption of AI, blockchain and immersive learning (Okafor & Ibrahim, 2023).

Financial constraints, lack of faculty training and skepticism toward decentralized technologies also impede progress (Adegbite & Nwankwo, 2022). To bridge the digital divide and improve skills training, it is crucial to understand the barriers and strategies for Web 3.0 adoption. Without understanding how lecturers and students engage with these technologies, the TVET sector risks falling behind global trends, leaving graduates unprepared for the digital economy and Industry 4.0 challenges (Bello & Olatunji, 2023). While previous research has focused on Web 2.0 tools, there is limited data on the use and readiness of Web 3.0 in Nigerian TVET programs. This study aims to assess the perceptions and use of Web 3.0 in South-South Nigerian universities, offering insights on enhancing technical education and preparing students for a digital workforce.

Objectives of the Study

1. examine the perceptions of TVET lecturers towards the adoption of Web 3.0 technologies for teaching and learning.

2. assess the extent are TVET lecturers utilized Web 3.0 technologies for teaching and learning in Nigerian Universities.
3. identify the challenges faced by lecturers in utilizing Web 3.0 technologies for teaching and learning in Nigerian Universities.

Research Questions

To achieve the objectives of this study, the following research questions were formulated to guide the study:

1. What are the perceptions of TVET lecturers towards the adoption of Web 3.0 technologies for teaching and learning?
2. To what extent are TVET lecturers utilized Web 3.0 technologies for teaching and learning in Nigerian Universities?
3. What challenges do lecturers face in utilizing Web 3.0 technologies for teaching and learning in Nigerian Universities?

Null Hypotheses

The following null hypotheses were formulated to guide the study:

$H0_1$: There is no significant difference in the perceptions of TVET lecturers towards the adoption of Web 3.0 technologies for teaching and learning.

$H0_2$: There is no significant difference in the mean response of TVET lecturers on the extent of utilization of Web 3.0 technologies for teaching and learning in Nigerian Universities.

$H0_3$: There is no significant difference in the mean response of TVET lecturers on the challenges of utilization of Web 3.0 technologies for teaching and learning in Nigerian Universities.

Review of Related Literature

Owo and Udoka (2021) assessed the perceptions of educational stakeholders on e-learning technology use for quality instruction in Nigerian universities. Using a descriptive survey design, they collected data from 168 participants (44 lecturers and 124 students) via questionnaires. Descriptive statistics, including mean and standard deviation, were applied to analyze the responses. The study found that many Nigerian universities lacked sufficient digital infrastructure for e-teaching and both lecturers and students required digital skills for successful e-learning. The researchers recommended that the government, in collaboration with universities, provide adequate ICT equipment and offer ICT training programs for both lecturers and students to ensure effective e-learning implementation.

Dauda, Danladi and Azubuike (2024) studied teachers' perceptions of ICT use in teaching and learning in upper basic schools in Kaduna State, Nigeria, focusing on Social Studies teachers' views on platforms like Facebook, WhatsApp, video conferencing and Instagram. A sample of 382 teachers was selected from 1,128 Social Studies teachers and data was collected via a self-structured questionnaire. The data were analyzed using mean and standard deviation. The study found that teachers believed ICT significantly impacted Social Studies teaching and learning. The researchers recommended providing teachers with opportunities to acquire the knowledge and skills necessary for effective Social Studies instruction in Kaduna State and nationwide.

Enyi and Otu (2021) studied teachers' perceptions of using ICT in Biology teaching in secondary schools within the Okposi education zone of Ebonyi State. The study involved all 15 Biology teachers from 10 schools and used a descriptive survey design. Data were collected through a checklist to assess ICT facilities and a questionnaire to measure teachers' perceptions and challenges. Simple percentages, mean and t-test were used for analysis. The

findings showed that many schools lacked adequate ICT facilities and although teachers recognized the benefits of ICT integration, they faced significant challenges in its use. Similarly, Fabunmi (2020) examined undergraduate students' views on the effectiveness of ICT in enhancing teaching and learning at Ekiti State University, Nigeria. Using a questionnaire within a survey design, the study revealed that students favored ICT over traditional book-based sources, despite its higher cost. It also found that students often relied on internet centers for ICT-based learning. The study emphasized the need to promote ICT use in Nigerian universities to improve teaching and learning, acknowledging its importance in global higher education.

Methodology

Design of the Study

The study used the descriptive survey design which is suitable for this study in terms of conditions, practices, views, beliefs, processes, relationships or trends. According to Nworgu (2018), survey research design aims to systematically collect and describe data concerning the characteristics, features or facts about a given population.

Area of Study

The study was conducted in South-South, Nigeria which is one of the six geopolitical zones in the country and a region of significant socio-economic and environmental importance. The zone is comprised of six states; Akwa Ibom, Bayelsa, Cross River, Delta, Edo and Rivers (Esara, Asuquo & Udoh, 2024). This region is notable for its diverse socio-cultural composition, rich natural resources, particularly oil and natural gas reserves, which contribute over 80% of Nigerian total export earnings and about 70% of government revenue (NBS, 2022). The region is also culturally diverse, home to over 40 ethnic groups including the Ijaw, Ibibio, Urhobo and Itsekiri, which contributes to the complexity of governance and social integration (NPC, 2019).

Population of the Study

The population of 128 respondents which comprised of 96 Male and 32 Female TVET lecturers in Universities in South-South, Nigeria was used for the study. According to Bornstein, Jager and Putnick (2013), the entirety of all elements under observation, which constitutes all things in any field of investigation, is the study population.

Sample and Sampling Technique

Purposive sampling technique was used to select 105 respondents which comprised of 75 Male and 30 Female TVET lecturers from six Universities in South-South geopolitical zones in Nigeria. A sample refers to a section or subset of the study population chosen for investigation through a sampling process (Taherdoost, 2016). In the same vein, Nardi (2018), stated that sampling technique is essential for estimating the required data volume and comprehending the data gathering process within a population to fulfill the study objectives. Yamane formula was used for calculating the sample size. According to Islam (2018), the Yamane formula provides a simplified formula to calculate sample sizes.

Instrumentation

The data for the study were gathered from both primary and secondary sources. The primary data were collected using questionnaire while the secondary data were gathered from text books, journals and online materials indexed in Google Scholar, Research Gates, Scopus, among others. The researchers developed a 30-item structured questionnaire titled: Lecturers' Perception and Utilization of Web 3.0 Technologies in Nigerian Universities Questionnaire (LEPUWTNUQ). A questionnaire according to Nardi (2018) is the most common instrument

or technique used to acquire descriptive data from a sample group in survey research because the respondents have the advantage of supplying data and information from the source. The instrument was divided into five sections; A - D. Section A comprised of items eliciting information on staff demographic data, while sections B - D comprised of items on the perceptions, utilization and challenges of Web 3.0 technologies for teaching and learning in Universities in South-South, Nigeria. The instrument was designed with a 5-point rating scale of Strongly Agreed (SA=4.50-5.00), Moderately Agreed (MA=3.50-4.49), Lowly Agreed (LA=2.50-3.49), Undecided (U =1.50-2.49), Strongly Disagreed (SD =1.00-1.49) used to answer research questions.

Validation of the Instrument

The research instruments were given to three research experts for face validation. Two of the experts from the Department of Measurement and Evaluation and one expert in Department of Technical Education, Ignatius Ajuru University of Education Port Harcourt, Rivers State. These experts were requested to read through the instrument item by item, make corrections, indicate the suitability of the items, language used and the arrangement of the items in logical and chronological sequence. Their comments, suggestions, corrections and other inputs were included in the instrument and used for the final copy.

Reliability of the Instrument

To ensure the reliability of the instrument, it was trial-tested on 20 students who were not part of the study. Cronbach alpha statistics was used to determine the reliability coefficient of the instrument which yielded overall reliability index of .78 comprising of .83, .74 and .77 for section B, C, D and E respectively indicating that the instrument was reliable. Cronbach's alpha test according to Taber (2017) is the most commonly used method to assess the accuracy of scales with value between 0 and 1. Cronbach alpha coefficient should be between 0.7 and above to demonstrate the scale reliability (Cronbach, 1951).

Method of Data Collection

The administration of the instrument was done with the assistance of three research assistants who were briefed before administration of the instrument to the students. A letter of information and consent were part of the information provided to the students. Since the questionnaire was distributed face to face, the participants read the letter of information and consent form and confirmed their voluntary participation. The one hundred and one hundred (100) copies of the questionnaire administered were all retrieved, indicating a 100% instrument retrieval.

Data Analysis

Mean scores and Standard Deviation were used in answering the research questions while t-test statistics was used to test the three null hypotheses at .05 level of significance. The data collected were analyzed using Statistical Package for the Social Sciences 26 (SPSS).

Results and Analysis of Results

The data analysis and interpretation of results are presented according to the research questions and hypothesis formulated for the study. Data of each research question are presented on a separate table to aid comprehension of the analysis and interpretation of results.

Research Question 1: What are the perceptions of TVET lecturers towards the adoption of Web 3.0 technologies for teaching and learning in Nigerian Universities?

Table 1: *Mean rating of the perceptions of TVET lecturers towards the adoption of Web 3.0 technologies for teaching and learning in Nigerian Universities.*

S/N	SECTION B: Perceptions of TVET lecturers towards the adoption of Web 3.0 technologies for teaching and learning	Male (N=75)		Female (N=30)	
		$\bar{x}$	SD	$\bar{x}$	SD
1.	I am aware of Web 3.0 technologies like AI, blockchain, VR, AR, decentralized platforms and the Semantic Web.	4.71	0.82	4.58	0.69
2.	Web 3.0 could make VTE learning more interactive and engaging.	4.53	0.67	4.62	0.86
3.	Web 3.0 enables personalized learning based on individual needs.	4.51	0.75	4.67	0.34
4.	VR and AR can enhance practical demonstrations of vocational skills.	4.74	0.73	4.56	0.57
5.	Blockchain can improve the credibility and transparency of assessment records.	4.62	0.56	4.79	0.48
6.	Web 3.0 fosters collaboration between students and lecturers.	4.86	0.48	4.66	0.44
7.	Web 3.0 can increase student motivation and engagement.	4.75	0.54	4.84	0.69
8.	Web 3.0 technologies help bridge theory and practical application.	4.78	0.52	4.53	0.53
9.	AI tools can assist lecturers with timely feedback.	4.64	0.67	4.57	0.71
10.	Web 3.0 expands hands-on learning opportunities in vocational education.	4.52	0.46	4.61	0.57
	Grand Mean and Standard Deviation	**4.67**	**0.62**	**4.64**	**0.59**

***NOTE:** SA (4.50-5.00), MA (3.50-4.49), LA (2.50-3.49), U (1.50-2.49), SD (1.00-1.49)

The analysis of data in Table 1 revealed that both male ($\bar{x}$ = 4.67, SD = 0.62) and female ($\bar{x}$ = 4.64, SD = 0.59) TVET lecturers strongly agreed with all the items on the perception of Web 3.0 technologies for teaching and learning in Nigerian universities. The high mean ratings across all items indicated a generally positive perception, with lecturers acknowledging the potential of Web 3.0 tools such as AI, blockchain, VR, AR and decentralized platforms to transform vocational and technical education. Specifically, the highest perceptions were expressed on Web 3.0 fostering collaboration between students and lecturers (male $\bar{x}$ = 4.86; female $\bar{x}$ = 4.66) and enhancing student motivation and engagement (male $\bar{x}$ = 4.75; female $\bar{x}$ = 4.84). Similarly, blockchain for credible records (female $\bar{x}$ = 4.79) and VR/AR for skill demonstrations (male $\bar{x}$ = 4.74) received very high agreement. The results showed that lecturers, regardless of gender, were aware of and optimistic about the transformative role of Web 3.0 in making learning more interactive, personalized and practice-oriented.

Research Question 2: To what extent are TVET lecturers utilized Web 3.0 technologies for teaching and learning in Nigerian Universities?

Table 2: *Mean rating of the utilization of web 3.0 technologies by TVET lecturers for teaching and learning in Nigerian Universities.*

S/N	SECTION C: Extent of Utilization of Web 3.0 Technologies in Universities.	Male (N=75)		Female (N=30)	
		$\bar{x}$	SD	SD	$\bar{x}$
1.	I use Web 3.0 tools such as AI, blockchain, VR, AR, decentralized platforms, Semantic Web in my teaching.	3.28	0.56	2.88	0.39
2.	My students engage with Web 3.0 technologies during learning activities.	3.01	0.38	3.29	0.51
3.	I use VR tools for practical demonstrations in VTE programs.	3.34	0.65	3.47	0.37
4.	I incorporate AI-powered tools (e.g., chatbots, adaptive platforms) for personalized learning.	3.37	0.88	3.26	0.55
5.	Web 3.0 technologies are regularly incorporated into student assessments and feedback processes in my courses	3.16	0.74	2.78	0.53
6.	I use the Semantic Web to organize and share course materials online.	2.81	0.73	3.45	0.57
7.	I utilize online collaboration tools enabled by Web 3.0 technologies to encourage student participation in group projects	3.23	0.66	2.93	0.60
8.	I use blockchain platforms for assignment submission and record management.	3.49	0.75	3.45	0.59
9.	Blockchain technology is utilized in my courses for securing academic records or certifications	2.97	0.43	3.41	0.66
10.	Students have easy access to VR, AR and AI tools for skill development.	3.35	0.60	3.24	0.44
	Grand Mean and Standard Deviation	**3.20**	**0.64**	**3.22**	**0.52**

***NOTE:** SA (4.50-5.00), MA (3.50-4.49), LA (2.50-3.49), U (1.50-2.49), SD (1.00-1.49)

The analysis of data in Table 2 showed that both male ($\bar{x}$ = 3.20, SD = 0.64) and female ($\bar{x}$ = 3.22, SD = 0.52) TVET lecturers reported only a moderate extent of utilization of Web 3.0 technologies for teaching and learning in Nigerian universities. While lecturers had demonstrated strong awareness and positive perceptions in Research Question 1, their actual use of these tools in practice remained limited. The mean ratings indicated occasional use of AI-powered platforms, VR tools and blockchain for record management, but none of the items reached the threshold of high utilization ($\bar{x}$ = 4.50 and above). Notably, blockchain applications (male $\bar{x}$ = 3.49; female $\bar{x}$ = 3.45) and VR demonstrations (female $\bar{x}$ = 3.47) showed relatively higher usage compared to other tools, while the Semantic Web (male $\bar{x}$ = 2.81) and integration into assessments (female $\bar{x}$ = 2.78) recorded the lowest levels of adoption. The closeness of the grand mean values revealed that the extent of utilization was consistent across genders, with no substantial difference.

Research Question 3 What challenges do lecturers face in utilizing Web 3.0 technologies for teaching and learning in Nigerian Universities?

Table 3: *Mean rating of the challenges facing TVET lecturers in the utilization of Web 3.0 technologies for teaching and learning in Nigerian Universities.*

S/N	SECTION D: Challenges in Adopting and Utilizing Web 3.0 Technologies for VTE.	Male (N=75)		Female (N=30)	
		$\bar{x}$	SD	SD	$\bar{x}$
1.	I face difficulties integrating Web 3.0 technologies (AI, blockchain, VR, AR, etc.) into my teaching.	4.75	0.63	4.56	0.49
2.	The institution infrastructure does not support Web 3.0 adoption in VTE programs.	4.92	0.81	4.63	0.74
3.	Learning resources like VR content and AI apps are insufficient.	4.56	0.55	4.66	0.36
4.	Technical support and maintenance for digital tools are lacking.	4.53	0.73	4.85	0.51
5.	The current curriculum does not accommodate Web 3.0 integration.	4.71	1.21	4.52	0.57
6.	Web 3.0 tools are not compatible with existing assessment methods.	4.57	0.64	4.61	0.73
7.	Students lack the technical skills to use Web 3.0 tools effectively.	4.61	0.70	4.58	0.37
8.	Unreliable internet access hinders Web 3.0 utilization.	4.64	1.62	4.76	0.52
9.	High costs of Web 3.0 tools are a major barrier for staff and students.	4.68	0.67	4.50	0.59
10.	I lack adequate training to use AI, VR and AR in teaching effectively.	4.83	0.76	4.62	0.70
	Grand Mean and Standard Deviation	**4.68**	**0.83**	**4.63**	**0.56**

***NOTE:** SA (4.50-5.00), MA (3.50-4.49), LA (2.50-3.49), U (1.50-2.49), SD (1.00-1.49)

The data in Table 3 revealed that TVET lecturers in Nigerian universities faced very high challenges in utilizing Web 3.0 technologies for teaching and learning, as indicated by the grand mean scores of 4.68 for male lecturers and 4.63 for female lecturers. The highest-rated challenges included lack of institutional infrastructure ($\bar{x}$ = 4.92, 4.63), inadequate training in the use of AI, VR and AR ($\bar{x}$ = 4.83, 4.62) and insufficient technical support ($\bar{x}$ = 4.53, 4.85), showing that both structural and human capacity gaps remained critical barriers. Similarly, unreliable internet access ($\bar{x}$ = 4.64, 4.76) and high costs of Web 3.0 tools ($\bar{x}$ = 4.68, 4.50) significantly limited effective adoption. Other challenges, such as insufficient learning resources, incompatibility with current assessment methods, lack of curriculum integration and students' poor technical skills, also recorded high mean ratings above 4.5, underscoring their severity.

Hypotheses 1: There is no significant difference in the perceptions of TVET lecturers towards the adoption of Web 3.0 technologies for teaching and learning.

Table 4: *t-test analysis of TVET lecturers' perceptions of Web 3.0 adoption in Nigerian Universities.*

Group	N	Mean ($\bar{x}$)	SD	df	t-value	p-value	Decision (α = 0.05)
Male Lecturers	75	4.67	0.62				
Female Lecturers	30	4.64	0.59	103	0.23	0.817	Not Significant

The result of the independent samples t-test in Table 4 showed that there was no significant difference between the mean perception scores of male ($\bar{x}$ = 4.67) and female ($\bar{x}$ = 4.64) TVET lecturers towards the adoption of Web 3.0 technologies for teaching and learning in Nigerian universities, t(103) = 0.23, p = 0.817 > 0.05. Therefore, the null hypothesis, which stated that there was no significant difference in the perceptions of TVET lecturers towards the adoption of Web 3.0 technologies for teaching and learning, was retained.

Hypotheses 2: There is no significant difference in the mean response of TVET lecturers on the extent of utilization of Web 3.0 technologies for teaching and learning in Nigerian Universities.

Table 5: *t-test analysis of TVET lecturers' utilization of Web 3.0 technologies in Nigerian Universities.*

Group	N	Mean ($\bar{x}$)	SD	df	t-value	p-value	Decision (α = 0.05)
Male Lecturers	75	3.20	0.64	103	-0.17	0.868	Not Significant
Female Lecturers	30	3.22	0.52				

The independent samples t-test in Table 5 showed no significant difference between male and female lecturers regarding the extent of Web 3.0 technology utilization (p = 0.868 > 0.05). Therefore, Hypothesis 2, which stated that there was no significant difference in the utilization of Web 3.0 technologies between male and female TVET lecturers, was retained. This suggested that both genders utilized Web 3.0 technologies at similar levels in Nigerian universities.

Hypotheses 3: There is no significant difference in the mean response of TVET lecturers on the challenges of utilization of Web 3.0 technologies for teaching and learning in Nigerian Universities.

Table 6: *t-test analysis of challenges facing TVET lecturers in Web 3.0 utilization in Nigerian Universities.*

Group	N	Mean ($\bar{x}$)	SD	df	t-value	p-value	Decision (α = 0.05)
Male Lecturers	75	4.68	0.83	103	0.36	0.722	Not Significant
Female Lecturers	30	4.63	0.56				

The t-test result in Table 6 indicated no significant difference between male and female lecturers in the challenges faced when using Web 3.0 technologies (p = 0.722 > 0.05). Hence, Hypothesis 3, which stated that there was no significant difference in the challenges encountered by male and female lecturers, was retained. Both genders encountered similar barriers, including limitations in infrastructure, technical support and training.

Discussion of Findings

The findings for Research Question One revealed that TVET lecturers in Nigerian universities held positive perceptions toward the adoption of Web 3.0 technologies for teaching and learning, with no significant gender-based differences, as confirmed by the corresponding hypothesis. Lecturers recognized the potential of AI, blockchain, virtual and augmented reality and decentralized platforms to enhance instructional interactivity, personalized learning, student engagement and practical skill acquisition. These findings align with Owo and Udoka (2021), who observed that lecturers value ICT integration for quality instruction and with Enyi and Otu (2021), who reported that educators acknowledge the pedagogical benefits of digital technologies despite infrastructural limitations. Fabunmi (2020) further corroborated the finding by demonstrating that students and lecturers favor ICT-mediated learning over traditional methods due to its capacity to improve learning outcomes. Conversely, Idhalama, Krubu and Etebu (2023) noted that lecturers' awareness

does not always translate into adoption, highlighting the need for professional development and exposure to new technologies.

The findings for Research Question Two revealed that the extent of Web 3.0 technology utilization by TVET lecturers in Nigerian universities was moderate, with no significant gender-based differences, supporting Hypothesis 2, which posited no difference in mean responses on utilization. Although lecturers demonstrated awareness of AI, blockchain, virtual and augmented reality and decentralized platforms, their actual application in teaching, learning and assessment practices remained constrained, indicating a gap between positive perception and practical adoption. These findings align with Owo and Udoka (2021) and Enyi and Out (2021), who reported that educators, despite recognizing ICT's pedagogical benefits, often underutilized technology due to limited infrastructure, insufficient technical support and inadequate access to resources. Similarly, Dauda, Danladi and Azubuike (2024) observed that positive attitudes toward digital tools did not automatically translate into frequent utilization. Conversely, Fabunmi (2020) noted that in institutions with adequate digital infrastructure, active use of ICT significantly enhanced teaching and learning outcomes.

The findings for Research Question Three revealed that TVET lecturers faced multiple challenges in utilizing Web 3.0 technologies for teaching and learning in Nigerian universities, with no significant gender-based differences observed, supporting Hypothesis 3, which posited no significant difference in the challenges experienced by male and female lecturers. Key obstacles included inadequate institutional infrastructure, insufficient technical support, lack of access to learning resources such as VR content and AI tools, limited digital skills among students, high costs of technology and curriculum misalignment with Web 3.0 integration. These findings align with Owo and Udoka (2021) and Enyi and Otu (2021), who reported that despite recognizing ICT pedagogical benefits, educators were constrained by poor infrastructure, lack of technical assistance and limited access to digital resources. Similarly, Luo (2010) and Idhalama, Krubu and Etebu (2023) highlighted that limited digital literacy and inadequate training hindered effective technology adoption in Nigerian higher education. The findings underscore the critical need for institutional interventions, including professional development programs, enhanced technical support, provision of digital tools and curriculum redesign, to address these barriers (Adu, Eze & Salako, 2014; Okolie, Igwe & Elom, 2019; Nwokocha & Ezenwaji, 2020).

Conclusion

The study concludes that TVET lecturers in Nigerian universities possess positive perceptions toward Web 3.0 technologies and recognize their potential to enhance interactive, personalized and practical learning in technical education. However, despite this favorable perception, actual utilization of these technologies remains moderate, constrained by infrastructural deficiencies, limited access to digital tools, inadequate technical support, curriculum misalignment, high costs and gaps in digital skills among both lecturers and students. No significant gender differences were observed across perceptions, utilization or challenges, indicating that these factors are consistent across male and female lecturers. Overall, the findings underscore a gap between lecturers' awareness of Web 3.0 potential and its practical integration into TVET programs. To fully harness these technologies, strategic institutional interventions such as capacity-building initiatives, investment in digital infrastructure, provision of accessible learning resources and curriculum redesign are essential. Effective implementation of these measures can bridge the perception-utilization gap, enhance instructional quality, foster competency-based skill acquisition and prepare students for the demands of a digitalized workforce in line with global trends in technical and vocational education.

Recommendations

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

1. Universities should invest in robust digital infrastructure to support the integration of Web 3.0 technologies in TVET programs.
2. Regular professional development and training programs should be organized to enhance lecturers' competence in using AI, VR, AR, blockchain and other Web 3.0 tools.
3. Curriculum revisions should be implemented to incorporate Web 3.0 technologies and ensure alignment with modern industry demands.
4. Institutions should provide accessible learning resources, including VR content, AI applications and blockchain platforms, to facilitate practical and interactive learning.
5. Sustainable funding and technical support units should be established to address cost barriers, maintenance issues and technological challenges in adopting Web 3.0 tools.

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