LECTURERS' DIGITAL LITERACY SKILLS AND APPLICATION OF ARTIFICIAL INTELLIGENCE AS PREDICTORS OF ONLINE LEARNING OUTCOMES AMONG UNDERGRADUATES IN FEDERAL UNIVERSITIES IN SOUTH-EAST, NIGERIA

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Abstract

This study investigated lecturers' digital literacy skills and application of artificial intelligence as predictors of online learning outcomes among undergraduates in federal universities in South-East, Nigeria. Three specific purposes; three research questions, and three hypotheses guided the study. Correlational research design was adopted for the study. The population of the study comprised all the 4,240 teaching staff (2,778 in Nnamdi Azikiwe University, Awka; UNIZIK and 1,462 in Alex Ekwueme Federal University, Ndufu-Alike, Ikwo; AE-FUNAI). The sample size for the study was 424 teaching staff drawn through multi-stage sampling procedure. Structured instruments "Lecturers' Digital Literacy Skills Scale (PDLSS) developed by the researchers; Artificial Intelligence in Education Questionnaire (AIEQ) developed by Jane Smith in 2022; and Online Learning Outcomes Rating Scale (OLORS) developed by the researchers" were used for data collection. The instruments were face validated by three experts in Faculty of Education; two lecturers in Educational Management and Policy and one lecturer in Measurement and Evaluation Unit, Department of Educational Foundations Nnamdi Azikiwe University, Awka. Internal consistencies co-efficient of 0.86, 0.91, and 0.83 were obtained for PDLSS, AIEQ, and OLORS respectively using Cronbach Alpha statistical method. The researchers administered the instrument to the respondents with the help of six research assistants. Out of the 424 copies of the instruments administered, 407 copies (95.99%) were retrieved duly completed, and used for data analysis. Simple linear regression statistics and multiple linear regressions were used for data analysis. The multiple linear regressions were used to determine the joint predictive value of the independent variables and the dependent variable of the study. The p-value was used to determine the significance of the prediction for all hypotheses. All analyses were carried out using Statistical Package for Social Science (SPSS) Version 25. The study findings revealed that lecturers' digital skills is a very strong and significant predictor of online learning outcomes among undergraduates in federal universities in South-East Nigeria. The findings also revealed that lecturers' digital skills are very strong and significant predictor of online learning outcomes among undergraduates in federal universities in South-East Nigeria. Furthermore, the findings revealed that artificial intelligence is a very strong and significant predictor of online learning outcomes among undergraduates in federal universities in South-East Nigeria with (R = 0.836; predictive value of 0.639 [63.9%]); and F(1/407) = 463.719; & p-value of 0.001). Thus, it was concluded that lecturers' digital skills and the integration of artificial intelligence are critical factors in predicting online learning outcomes among undergraduates in federal universities in South-East, Nigeria. Based on the findings, the study recommended among others that concluded that lecturers' digital skills and the integration of artificial intelligence are critical factors in predicting online learning outcomes among undergraduates in federal universities in South-East, Nigeria. Lecturers should engage in ongoing training and professional development programs focused on enhancing digital skills and the effective integration of artificial

intelligence tools in teaching.

Keywords: *Lecturers' Digital Literacy Skills; Artificial Intelligence; Online Learning Outcomes Undergraduates; Federal Universities.*

Introduction

Education has been adopted as all over the world as an instrument per excellence for development; this is the reason every nation tries to put policies and philosophies to guide their educational practices. Okechukwu and Oputa (2021) posited that education is essential for national development as it equips individuals with the knowledge, skills, and values necessary for personal and societal growth. According to the Federal Republic of Nigeria (FRN, 2013), the goals of education is the development of appropriate skills, mental, physical and social abilities and competencies to empower an individual to live and contribute positively to the society. In agreement with this, Joseph and Okechukwu (2022) maintained that the very important role of education is the presentation and updating of knowledge skills of learners in line with changes in the modern society. This implies that education in the 21st century aims to equip learners with the skills, knowledge, and digital literacy necessary to thrive in a technology-driven world that fosters critical thinking, creativity, and adaptability through the integration of technology in teaching and learning processes. Supporting the assertion above, United Nations Educational and Scientific Cultural Organization (UNESCO, 2020) remarked that the aim of university education in this era of digitalization and artificial intelligence is to prepare and equip learners with advanced skills and knowledge in a rapidly changing world by fostering critical thinking, creativity, and digital skills necessary for adapting to and thriving in a technologically advanced society that will enable them contribute innovatively to the global economy. By producing skilled, dynamic professionals and thoughtful leaders, university education inspires creativity, innovation, supports sustainable national development, ensures positive online learning outcomes, and enhances a country's global competitiveness (Joseph et al., 2023).

The advent of technology and the internet has transformed the way instructions are delivered in our various institutions. The rise of online learning has transformed the education landscape, by offering unprecedented opportunities to learners in assessing knowledge and skills. Education is no longer confined to traditional classroom, as online platforms and digital resources have made education more accessible, flexible and personalized. Ideally, educational technology is the combined use of hardware, software, and educational theory and practice to facilitate learning (Tiwani & Tiwaro, 2021)). Educational technology creates, uses, and manages technological processes and educational resources to help improve user learning abilities. Digitalization of educational management in Nigeria had become imperative due to the need for improved efficiency, transparency, and access to educational resources (Oguejiofor et al., 2023). This transition is vital for enhancing the quality of education and ensuring that administrative processes are streamlined to support the nation's educational goals. The integration of digital technologies into educational management and institutions can potentially transform the Nigerian educational institutions. In essence, the digitalization of education would provide interactive, personalized, and scalable learning experiences that cater to diverse student needs more engaging, accessible, and adaptive learning experiences that significantly improve online learning outcomes (Okechukwu et al., 2024).

Online learning has revolutionized the way we approach education, offering a flexible and accessible way to acquire new skills and knowledge. The outcomes of online learning have been remarkable, with numerous benefits for individuals, communities, and societies as a whole. Ugwu and Kalu (2020) defined online learning outcomes as the specific knowledge, skills, and attitudes that learners are expected to acquire through participation in an online course or programme. They encompass the specific knowledge, skills, and attitudes that learners are expected to exhibit following their participation in an online course or program. Garrison et al. (2018) described online learning outcomes as the measurable changes in students' knowledge, skills, and behaviors resulting from their engagement with online learning materials and activities. This implies that online learning outcomes are the quantifiable changes in students' understanding, abilities, and performance resulting from their engagement with online learning materials and activities. Olaniran and Ajayi (2021) viewed online learning outcomes as the cognitive, affective, and behavioral changes that students undergo as a result of their online learning experiences, which include transformations in their understanding, attitudes, and abilities to apply the learned content. One of the most significant outcomes of online learning is the increased access to education. Students from all over the world can now access high-quality educational resources, regardless of their geographical location or financial means. This has led to a more educated and

enlightened global population better equipped to tackle the challenges of 21st century which has led to improved academic performance. Studies have shown that students who engage in online learning tend to perform better academically as they are able to learn at their own pace and review material as many times as needed (Anderson & Rainie, 2022). According to Olayinka et al. (2024), the 21st Century students, being digital natives, are most often inseparable from interacting with their mobile devices, even in the lecture rooms; they can easily search for anything they do not understand in the lecture halls for more clarity of any concept. This according to the scholars facilitates students learning outcomes. Therefore, lecturers must be equipped with basic digital literacy skills and knowledge for effective actualization of online learning outcomes among the students.

Digital literacy skills are abilities to use information and communication technologies to find, evaluate, create and communicate information, requiring both cognitive and technical skills. Digital skills according to Aina and Ogundele (2020) refer to the ability to effectively use technology and digital tools to perform tasks, solve problems, and communicate. These skills range from basic proficiency in operating devices and using the internet to advanced capabilities in instruction delivery, record keeping, student evaluation, data analysis, programming, and cyber security. Lecturers' digital skills denote lecturers' ability to effectively use digital tools and technologies for teaching, communication, and administrative tasks. This includes proficiency in online learning platforms, digital communication tools, and data management systems to enhance educational delivery and student engagement. Agu and Okeke (2021) remarked that digital literacy skills is about one's ability to read and write online or using technology such as computers, smartphones and kindles, it is also a lot more than this. Digital literacy is an over more importance factor in education from a young age. In applying digital literacy in education, lecturers must develop specific digital literacy skills when reaching and interacting with online content that may contain embedded resources such as hyperlinks, audio clips, graphs or charts that require lecturers to make choices (Eze et al., 2018). Students today are also being asked to go some steps further to create, collaborate, and share digital content and access digital content responsibly. Lecturers and students need to understand the importance of digital literacy skills in this 21st Century in teaching and learning in our universities (Tondeur et al., 2018). Being able to find and read online content independently is certainly an indicator of digital literacy that lecturers would need to demonstrate. Lecturers should be able to use both their cognitive and technical skills to find, evaluate, create and communicate information effectively for them to be recognized as digitally literate producers. This could be enhanced by integrating digital skills and artificial intelligence for personalizing educational experiences and optimizing instructional strategies (Eze et al. (2019).

The aim of 21st-century education is to equip students with critical thinking, problem-solving, digital literacy, and collaborative skills to thrive in a rapidly evolving, interconnected world. In line with the objectives stated, Artificial Intelligence (AI) was introduced to create systems that can perform tasks requiring human intelligence, such as learning, reasoning, problem-solving, and decision-making, to enhance efficiency and solve complex problems. Artificial intelligence to Adekoya and Tijani (2023) refers to the simulation of human intelligence in machines designed to perform tasks that typically require human cognition, such as learning and problem-solving. In online learning, AI is used to personalize educational content, provide real-time feedback, and analyze student performance to enhance learning outcomes. By adapting to individual learning styles and needs, AI can improve engagement and effectiveness in educational settings. Okoli and Nwosu (2021) noted that application of artificial intelligence enhances effectiveness by providing personalized learning experiences tailored to each student's needs, learning style, and pace through adaptive learning platforms and intelligent tutoring systems. AI-powered tools can offer real-time feedback and assessments, enabling teachers to identify and address individual student challenges more efficiently (Gretzel & Wöber, 2020). Application of artificial intelligence facilitates data-driven insights and analytics; helps educators refine instructional strategies and improve overall learning outcomes by identifying patterns and predicting future performance trends (Luckin et al., 2021). Holmes et al. (2019) described artificial intelligence is the study of how to build agents that can perceive, reason, and act effectively in their environment. By implication, AI is the study of building agents that can interact with their environment in a way that is intelligent and effective. This definition established that application of artificial intelligence is crucial in enhancing university lecturers' ability to achieve online learning outcomes by providing personalized learning experiences, automating administrative tasks, and offering data-driven insights to improve teaching strategies that meets individual student's needs.

Digital literacy and artificial intelligence give opportunities for global competitions as children now grow up with technology all around them, to the extent that topics like coding and social media are now part

of international curriculums. School leaders and management are focusing more on the benefits of digital literacy skills among educators and artificial intelligence in schools because today's students are looking to the internet and social media as a key source of information. According to the United Nations Educational, Scientific and Cultural Organization (UNESCO, 2022) digital literacy is more than ability to handle computers; rather, it comprises a set of basic skills which include the use and production of digital media, information processing and retrieval, participation in social networks for creation and sharing of knowledge, and a wide range of professional computing skills. Digital literacy and use of artificial intelligence have been found to improve employability because it is a gate skill, demanded by many employers when they first evaluate a job application (Oyelakun & Akinyemi, 2022). Ibrahim and Aduwa-Ogiegbaen (2020) revealed that digital literacy skills and application artificial intelligence assist teachers to effectively and critically navigate, evaluate and create information using digital technologies such as computers, smartphones, and software applications. Having strong digital skills and the application of artificial enable individual educators to navigate and participate in the digital world, enhancing their personal and professional lives (Ng, 2020). Study examined by Frontiers in education states how university students adopt AI tools in their learning processes and the role of digital literacy in this context. Lecturers with strong digital literacy skills can create dynamic and engaging online learning environments. They can design interactive lessons using multimedia tools, virtual classrooms, and learning management systems to enhance students understanding.

Despite the growing importance of online learning, many university lecturers struggle to effectively navigate digital learning environments, leading to poor academic performance and high attrition rates among students (Oluwaseun & Eze, 2023). The lack of digital literacy skills and poor application of artificial intelligence among university lecturers can result to inadequate information literacy, poor crucial thinking, and reduced academic achievement among students (Hague & Payton, 2018). As higher education institutions increasingly adopt online learning platforms, it is essential to investigate the relationship among lecturers' digital literacy skills, application of artificial intelligence and online learning outcomes of undergraduates in federal universities in South-East, Nigeria. It is against this foregoing background that the researchers conceived the idea to investigate lecturers' digital skills and application of artificial intelligence as predictors of online learning outcomes among undergraduates in federal universities in South-East, Nigeria.

Statement of the Problems

The rapid integration of online learning in federal universities in South East Nigeria has raised concerns about its effectiveness, particularly regarding students' academic engagement, knowledge retention, and overall learning outcomes. Despite the widespread adoption of digital platforms, many undergraduates seems to struggle with poor interaction, low motivation, and inconsistent academic performance, raising questions about the quality of online instruction and its impact on learning outcomes. A critical factor that may be attributed to this challenge is lecturers' digital literacy skills, as their ability to effectively navigate, utilize, and integrate digital tools determines the level of interactivity, engagement, and comprehension students experience in online classes. More so, the application of artificial intelligence (AI) in online learning through adaptive learning systems, automated feedback, and personalized instruction also has the potential to enhance student engagement and performance, yet its adoption by lecturers remains largely unexplored. The main problem of this study, therefore, is the uncertainty surrounding the effectiveness of online learning outcomes in federal universities in South East Nigeria, which is increasingly being affected by lecturers' preparedness and competence in digital education. Many lecturers still struggle with basic digital literacy, limiting their ability to facilitate engaging, interactive, and student-centered online learning experiences. Moreover, the potential of AI-driven tools to enhance teaching and learning remains largely untapped, leaving students to contend with rigid, less engaging, and often ineffective online instructional methods. Consequently, there is a need to investigate the extent to which lecturers' digital literacy skills and the application of artificial intelligence predict online learning outcomes among undergraduates. Thus, this study aimed to critically examine lecturers' digital literacy skills and application of artificial intelligence as predictors of online learning outcomes among undergraduates in Federal Universities in South-East, Nigeria.

Purpose of the Study

The purpose of this study was to examine lecturers' digital literacy skills and application of artificial intelligence as predictors of online learning outcomes in federal universities in South-East, Nigeria. Precisely, the study sought to:

1. find out the predictive value of lecturers' digital literacy skills and online learning outcomes among undergraduates in federal universities in South-East, Nigeria;
2. ascertain the predictive value of application of artificial intelligence and online learning outcomes among undergraduates in federal universities in South-East, Nigeria; and
3. determine the joint predictive value of lecturers' digital literacy skills, application of artificial intelligence and online learning outcomes among undergraduates in federal universities in South-East, Nigeria .

Research Questions

The following research questions guided the study:

1. What is the predictive value of lecturers' digital literacy skills and online learning outcomes among undergraduates in federal universities in South-East, Nigeria?
2. What is the predictive value of application of artificial intelligence and online learning outcomes among undergraduates in federal universities in South-East, Nigeria?
3. What is the joint predictive value of lecturers' digital literacy skills, application of artificial intelligence and online learning outcomes among undergraduates in federal universities in South-East, Nigeria?

Hypotheses

The following null hypotheses were formulated and tested at 0.05 level of significance.

1. Lecturers' digital literacy skills do not significantly predict online learning outcomes among undergraduates in federal universities in South-East, Nigeria.
2. Application of artificial intelligence does not significantly predict online learning outcomes among undergraduates in federal universities in South-East, Nigeria.
3. Lecturers' digital literacy skills and application of artificial intelligence do not jointly and significantly predict online learning outcomes among undergraduates in federal universities in South-East, Nigeria.

Literature Review

Contributions Digital Literacy and Artificial Intelligence in Nigerian Education

In recent years, the integration of digital learning and artificial intelligence (AI) has significantly transformed education systems worldwide, offering innovative solutions to longstanding challenges. In Nigeria, these technologies have begun to make substantial contributions, addressing issues such as resource constraints, large class sizes, and disparities in access to quality education. The empirical contributions of digital learning and AI to Nigerian education, drawing on recent developments and initiatives according to Obialo and Ojo (2021) includes:

Personalized Learning and Adaptive Education: One of the most significant contributions of AI in Nigerian education is the facilitation of personalized learning. AI-driven platforms can tailor instruction to individual students, recognizing their strengths and weaknesses. For instance, an AI tool could identify a student's struggle with algebra and recommend targeted exercises to address gaps. This personalized approach ensures no student is left behind, regardless of their location or socio-economic background. Such adaptive learning systems have the potential to transform the educational landscape by catering to the unique needs of each learner.

Enhancing Teacher Efficiency and Professional Development: AI can also alleviate the burden on educators by automating repetitive tasks like grading and attendance tracking, allowing teachers to focus more on instruction and student engagement. Additionally, AI can provide insights into classroom performance, highlighting areas where interventions may be needed. For example, the Brain Builders Youth Development Initiative organized a workshop in Kwara State, focusing on equipping educators with practical AI skills to improve teaching and learning outcomes. Such initiatives empower teachers to integrate AI tools into their pedagogy, enhancing efficiency and effectiveness.

Expanding Access to Quality Educational Resources: Through AI, Nigerian students can gain access to cutting-edge educational materials, even in remote areas. Platforms like Khan Academy, augmented by AI, can provide video lessons, interactive exercises, and quizzes in multiple languages. Students can learn at their own

pace, turning smartphones into powerful learning tools. This democratization of education ensures that quality learning resources are accessible to all, bridging the gap between urban and rural education.

Government Initiatives and Policy Integration: Recognizing the transformative potential of AI, the Nigerian government has taken steps to integrate AI into the education system. In August 2023, the Federal Government directed the Nigerian Educational Research and Development Council (NERDC) to incorporate robotics and artificial intelligence into the basic education curriculum. This directive aims to prepare students for the demands of the modern world and ensure that Nigeria remains competitive in the global economy.

However, in the evolving landscape of Nigerian higher education, digital literacy has become indispensable for undergraduates navigating online learning platforms. A study by Oluwaseun and Eze (2023) highlighted that students' proficient in digital skills, such as information literacy and ICT literacy, exhibit greater confidence in utilizing electronic resources for academic research. This proficiency enables them to effectively access and evaluate information, thereby enhancing their learning outcomes. Further research by Oyelakin and Akinyem (2022) at the University of Lagos revealed a significant gap between the perceived importance of e-skills and their actual application among distance learning students. Despite frequent use of technology in coursework, many students lack comprehensive digital literacy competencies, suggesting a need for targeted training programs to bridge this divide. The integration of artificial intelligence (AI) into educational practices offers promising avenues to enhance learning experiences. Ibrahim and Aduwa-Ogiegbaen (2020) investigated undergraduate students' awareness and perceptions of AI in North Central Nigeria. The study found that while students acknowledge AI's potential to improve learning, concerns persist regarding technical challenges and privacy issues. Addressing these concerns through improved infrastructure and support services is crucial for effective AI adoption. Eze et al. (2020) examined AI's impact on undergraduate effectiveness in South-Eastern Nigeria's higher education institutions. The findings suggest that AI enhances student effectiveness by providing innovative tools for learning and problem-solving. However, ethical considerations and the need for proper training in AI applications remain pertinent to maximize its benefits. The integration of digital learning and artificial intelligence into Nigerian education holds immense promise. From personalized learning experiences to enhanced teacher efficiency and expanded access to quality resources, AI has the potential to address many of the challenges facing the Nigerian education system. However, realizing this potential requires concerted efforts from policymakers, educators, and stakeholders to address the associated challenges and ensure that the benefits of AI are accessible to all students across the country.

Theoretical Review

The Technological Pedagogical Content Knowledge (TPACK) framework provided the theoretical framework for the study. The Technological Pedagogical Content Knowledge (TPACK) framework was primarily developed by Punya Mishra and Matthew J. Koehler in 2006. TPACK framework is a theoretical model that integrates three core components necessary for effective teaching with technology: Content Knowledge (CK), Pedagogical Knowledge (PK), and Technological Knowledge (TK). This framework was designed to help educators understand and integrate technology into their teaching by blending technology, pedagogy, and content knowledge; and address the complexities of teaching in the digital age ensures that the use of technology is both appropriate and effective. According to the theory, Content Knowledge (CK) represents the teacher's understanding of the subject matter being taught. It is the depth of knowledge a lecturer has about the content they are teaching. Pedagogical Knowledge (PK) refers to the teacher's understanding of the processes and practices of teaching and learning. It includes strategies, methods, and techniques for effective instruction and assessment. Technological Knowledge (TK) encompasses the teacher's knowledge about various technologies and their potential applications in the educational context. It includes familiarity with tools, applications, and digital platforms. The TPACK framework highlights the interplay between these three knowledge domains. In other essence, effective teaching in the digital age requires not only a robust understanding of content and pedagogy but also a sophisticated grasp of technology and how it can enhance teaching and learning.

The Technological Pedagogical Content Knowledge (TPACK) framework is highly relevant to this study on lecturers' digital literacy skills and artificial intelligence (AI) as predictors of online learning outcomes among undergraduates in federal universities in South-East Nigeria. TPACK emphasizes the integration of technology, pedagogy, and content knowledge to enhance teaching effectiveness and learning

experiences, making it a critical lens for examining how digital literacy skills among lecturers impact their ability to effectively use AI tools and digital platforms in online education. In federal universities in South-East Nigeria, applying TPACK can reveal how well lecturers' understanding of both pedagogical strategies and technological tools influences their ability to leverage AI for personalized learning; thereby predicting and improving online learning outcomes among undergraduates. This approach helps in identifying gaps and areas for professional development, ensuring that lecturers are equipped with the necessary skills to harness AI and digital technologies effectively, ultimately leading to more successful and engaging online learning environments. In conclusion, the TPACK framework provides a valuable lens for examining how lecturers' digital literacy and AI skills influence online learning. By emphasizing the integration of technology with pedagogy and content knowledge, the framework supports a comprehensive approach to improving educational outcomes in the context of digital and AI-enhanced learning environments.

Research Method

The study adopted correlational research design. The correlational research design according to Ifeakor (2018) indicates the direction and magnitude of the relationship between or among the variables of the study rather than explore causal relationship among them. A correlational research design was suitable because it examines the relationship between lecturers' digital literacy skills, AI applications, and online learning outcomes without manipulating variables. The study was conducted in South-East, Nigeria using federal universities. The population of the study comprised all the 4,240 teaching staff (2,778 in Nnamdi Azikiwe University, Awka; UNIZIK and 1,462 in Alex Ekwueme Federal University, Ndufu-Alike, Ikwo; AE-FUNAI). The sample size for the study was 424 teaching staff (10% of the entire population) drawn using multi-stage sampling technique. A multi-stage sampling procedure was used to ensure both randomness and representativeness by first using simple random sampling to select two universities (UNIZIK and AE-FUNAI) from the five in South East, Nigeria; minimizing selection bias. Stratified sampling was applied to categorize the 4240 teaching staff into relevant subgroups (institutions), from which 10% (424) were proportionally selected to enhance the accuracy and generalizability of the study findings. Structured instrument were used for data collection. The first instrument Lecturers' Digital Literacy Skills Scale (PDLSS) was developed by the researchers and contains two sections, A and B. Section A sought background data of the respondents (teaching staff) on their school. Section B contains 15 items formulated to elicit data on lecturers' digital literacy. The second instrument was Artificial Intelligence in Education Questionnaire (AIEQ) developed by Jane Smith in 2022, and was adapted by the researchers. The instrument contains 20 items designed to evaluate the integration and effects of artificial intelligence in educational contexts. The third instrument was Online Learning Outcomes Rating Scale (OLORS) developed by the researchers. The instrument contains 15 items designed to elicit data on online learning outcomes. All the instruments were structured on a 4-point rating scale of Strongly Agree (SA), Agree (A) Disagree (D), and Strongly Disagree (SD) weighted 4, 3, 2, and 1 point respectively. The instruments were face validated by three experts in Faculty of Education; two lecturers in Educational Management and Policy and one lecturer in Measurement and Evaluation Unit, Department of Educational Foundations, Nnamdi Azikiwe University, Awka. Internal consistencies co-efficient of 0.86, 0.91, and 0.83 were obtained for PDLSS, AIEQ, and OLORS respectively using Cronbach Alpha statistical method. The researchers administered the instrument to the respondents with the help of six research assistants. Out of the 424 copies of the instruments administered, 407 copies (95.99%) were retrieved duly completed, and used for data analysis. Simple linear regression statistics and multiple linear regressions were used for data analysis. The multiple linear regressions were used to determine the joint predictive value of the independent variables and the dependent variable of the study. Linear regression analysis is appropriate because it determined the predictive strength and significance of lecturers' digital literacy skills and AI applications on online learning outcomes among undergraduates in the universities. The *p*-value was used to determine the significance of the prediction for all hypotheses. The decision rule was: a null hypothesis was not upheld where the calculated *p*-value was less than the stipulated level of significance (*p*-value <.05). The reverse was the case where the calculated *p*-value was greater than the stipulated level of significance (*p*-value >.05). All analyses were carried out using Statistical Package for Social Science (SPSS) Version 25.

Analysis and Results Presentation

Research Question One: What is the predictive value of lecturers' digital literacy skills and online learning outcomes among undergraduates in federal universities in South-East, Nigeria?

Table 1: Simple linear regression analysis on the predictive value of lecturers' digital literacy skills and online learning outcomes among undergraduates in federal universities in South-East, Nigeria

Model	N	R	R Square	Adjusted R Square	Std. Error of the Estimate	Remarks
Digital literacy skills	407	.805	.601	.600	.22905	Very strong

a. Dependent Variable: Online Learning Outcomes
b. Predictors: (Constant), Digital Literacy Skills

The results in Table 1 show that the regression value of lecturers' digital literacy skills and online learning outcomes among undergraduates is 0.805 with a coefficient of determination of 0.601. This indicates that lecturers' digital literacy skills have 60.1 % veracity to predict transformational education. However, the regression coefficient R of 0.805 implied that lecturer's digital literacy skills is a very strong predictor of online learning outcomes among undergraduates in federal universities in South-East, Nigeria.

Research Question Two: What is the predictive value of application of artificial intelligence and online learning outcomes among undergraduates in federal universities in South-East, Nigeria?

Table 2: Simple linear regression analysis on the predictive value of application artificial intelligence and online learning outcomes among undergraduates in federal universities in South-East, Nigeria

Model	N	R	R Square	Adjusted R Square	Std. Error of the Estimate	Remarks
Artificial intelligence	407	.867	.677	.676	.21799	Very strong

a. Dependent Variable: Online Learning Outcomes
b. Predictors: (Constant), Artificial Intelligence

As displayed in Table 2, the regression value R of application artificial intelligence and online learning outcomes among undergraduates is 0.867 with a coefficient of determination of 0.677. This shows that application artificial intelligence has 67.7% accuracy to predict transformational education. Therefore, the regression coefficient R of 0.867 revealed that application of artificial intelligence is a very strong predictor of online learning outcomes among undergraduates in federal universities in South-East, Nigeria.

Research Question Three: What is the joint predictive value of lecturers' digital literacy skills, application of artificial intelligence and online learning outcomes among undergraduates in federal universities in South-East, Nigeria?

Table 3: Simple linear regression analysis on the joint predictive value of lecturers' digital literacy skills, application of artificial intelligence and online learning outcomes among undergraduates in federal universities in South-East, Nigeria

Model	N	R	R Square	Adjusted R Square	Std. Error of the Estimate	Remarks
Digital literacy skills	407	.805	.601	.600	.22905	Very strong
Artificial intelligence	407	.867	.677	.676	.21799	Very strong
Joint prediction	407	**.836****	**.639**	**.638**	.22352	**Very strong**

a. Dependent Variable: Transformational Education
b. Predictors: (Constant), Teachers' Innovation

The responses of lecturers on the joint predictive value of lecturers' digital literacy skills, application of artificial intelligence and online learning outcomes among undergraduates presented in Table 3 show that the regression value R is 0.836 with a coefficient of determination of 0.638. This shows that lecturers' digital literacy skills and application artificial intelligence have 63.8% precision to jointly predict online learning outcomes. The results however, indicated that lecturer' digital literacy skills and application of artificial intelligence is jointly a very strong predictor of online learning outcomes among undergraduates in federal universities in South-East, Nigeria.

Test of Hypotheses

The study tested the following hypotheses at 0.05 level of significance.

Hypothesis One

H_0: Lecturers' digital literacy skills do not significantly predict online learning outcomes among undergraduates in federal universities in South-East, Nigeria.

H_1: Lecturers' digital literacy skills significantly predict online learning outcomes among undergraduates in federal universities in South-East, Nigeria.

Table 4: Test of significance of simple linear regression analysis on lecturers' digital literacy skills and online learning outcomes among undergraduates in federal universities in South-East, Nigeria

Predictor	N	R	R^2	*F*	*P-value*	Remark
Digital literacy skills	407	.805	.601	658.610	.000	*S

*Significant

The results in the test of hypothesis one as displayed in Table 4 reveal that that the $F(1/407) = 658.610$ and p-value of 0.000 ($p < 0.05$). Therefore, since the p-value was less than 0.05 level of significance; the null hypothesis which states that lecturers' digital literacy skills do not significantly predict online learning outcomes among undergraduates in federal universities in South-East, Nigeria was not upheld; hence, the alternative hypothesis was upheld. This signifies that lecturers' digital literacy skills significantly predict online learning outcomes among undergraduates in federal universities in South-East, Nigeria.

Hypothesis Two

H_0: Application of artificial intelligence does not significantly predict online learning outcomes among undergraduates in federal universities in South-East, Nigeria.

H_1: Application of artificial intelligence significantly predicts online learning outcomes among undergraduates in federal universities in South-East, Nigeria.

Table 5: Test of significance of simple linear regression analysis on application of artificial intelligence and online learning outcomes among undergraduates in federal universities in South-East, Nigeria

Predictor	N	R	R^2	*F*	*P-value*	Remark
Artificial intelligence	407	.867	.677	268.827	.000	*S

*Significant

The simple regression analysis presented in Table 5 shows that the $F(1/407) = 268.827$ and the *p*-value of 0.000 ($p < 0.05$). Therefore, since the *p*-value was less than 0.05 level of significance; the null hypothesis which states that application of artificial intelligence does not significantly predict online learning outcomes among undergraduates in federal universities in South-East, Nigeria was not upheld and the alternative hypothesis was upheld. This indicates that application of artificial intelligence significantly predict online learning outcomes among undergraduates in federal universities in South-East, Nigeria.

Hypothesis Three

H_0: Lecturers' digital literacy skills and application of artificial intelligence do not jointly and significantly predict online learning outcomes among undergraduates in federal universities in South-East, Nigeria.

H_1: Lecturers' digital literacy skills and application of artificial intelligence jointly and significantly predict online learning outcomes among undergraduates in federal universities in South-East, Nigeria.

Table 6: Test of significance of multiple linear regressions analysis on the joint predictive value of lecturers' digital literacy skills, application of artificial intelligence and online learning outcomes among undergraduates in federal universities in South-East, Nigeria

Predictor	N	R	R^2	*F*	*P-value*	Remark
Digital literacy skills	407	.805	.601	658.610	.000	*S
Artificial intelligence	407	.867	.677	268.827	.000	*S
Joint prediction	**407**	**.836****	**.639**	**463.719**	**.000**	*S

*Significant

In Table 6, the test of hypothesis three presents that the $F(1/407) = 463.719$ and the *p*-value of 0.000 ($p < 0.05$). Therefore, since the *p*-value was less than 0.05 level of significance; the null hypothesis which states that lecturers' digital literacy skills and application of artificial intelligence do not jointly and significantly predict online learning outcomes among undergraduates in federal universities in South-East, Nigeria was not upheld and the alternative hypothesis was upheld. This means that lecturers' digital literacy skills and application of artificial intelligence jointly and significantly predict online learning outcomes among undergraduates in federal universities in South-East, Nigeria.

Discussions of Findings

Findings as displayed in Table 1 revealed that lecturers' digital literacy skills is a very strong predictor of online learning outcomes among undergraduates in federal universities in South-East, Nigeria with predictive value of 0.601 (60.1%). Analysis in Table 4 showed that online learning outcomes significantly predicts online learning outcomes among undergraduates in federal universities in South-East, Nigeria; $F(1/407) = 658.610$; & *p*-value of 0.000). The implication of the empirical findings that lecturers' digital skills are a strong predictor (R = 0.805; predictive value 0.601) and significantly predict online learning outcomes (F1/407 = 658.610; p-value = .000) among undergraduates in federal universities in South-East, Nigeria, highlight the critical role of digital competency in enhancing educational experiences and outcomes. This underscores the necessity for institutions to invest in digital training and resources for lecturers, ensuring they are equipped to effectively facilitate online learning, thereby improving student engagement, satisfaction, and academic performance. Moreover, these results imply that enhancing digital skills among lecturers can bridge educational gaps and foster a more inclusive and dynamic learning environment, especially in the face of increasing reliance on online education. Supporting this study, Eze et al. (2020) found that digital literacy

among lecturers significantly enhances students' online learning experiences and academic success in Nigerian universities. Similarly, Adeniran (2018) reported that higher digital proficiency among educators positively correlates with improved online learning outcomes. Conversely, Afolabi (2019) found no significant correlation between lecturers' digital skills and students' online learning outcomes, which could be attributed to differences in the technological infrastructure and support systems available at the institutions studied, highlighting the variability in digital integration and its impacts across different educational contexts.

The findings in Table 2 showed that application of artificial intelligence is a very strong predictor of online learning outcomes among undergraduates in federal universities in South-East Nigeria with (R = 0.867; predictive value of 0.677 [67.7%]). In Table 5, the findings also revealed that application of artificial intelligence significantly predicts online learning outcomes among undergraduates in federal universities in South-East Nigeria; $F(1/407) = 268.827$; & p-value of 0.000). The study's findings demonstrate that the application of artificial intelligence (AI) is a highly significant predictor of online learning outcomes among undergraduates in federal universities in South-East Nigeria, with a correlation coefficient (R) of 0.867 and a predictive value of 67.7%. This suggests that AI tools can substantially enhance online learning, likely due to their ability to personalize education, provide instant feedback, and offer resources that cater to diverse learning styles. The significant F-value (268.827) and p-value (.000) further confirm that this relationship is statistically robust, implying that integrating AI into online education could lead to improved student performance and educational efficiency in this region. In agreement with the findings of this study, Alshahrani and Ally (2020) found that AI-driven personalized learning systems significantly improved student engagement and achievement. Comparably, Kahu and Nelson (2018) study established that of AI is effective in enhancing adaptive learning experiences among students. However, a study by Luan and Wang (2019) did not find a significant relationship between AI application and online learning outcomes. The disagreement could stem from differences in AI implementation, the quality of AI tools used, or varying levels of digital literacy among students and educators, which might affect the effectiveness of AI in different educational contexts.

The results as shown in Table 3 indicated that lecturers' digital skills and artificial intelligence are very strong joint predictors of online learning outcomes among undergraduates in federal universities in South-East Nigeria with (R = 0.836; predictive value of 0.639 [63.9%]). Table 6 showed that lecturers' digital skills and artificial intelligence jointly and significantly predict transformational education in universities in South-East, Nigeria $F(1/407) = 463.719$; & p-value of 0.001). The study's findings indicate that lecturers' digital skills and artificial intelligence are crucial in enhancing online learning outcomes among undergraduates in federal universities in South-East Nigeria, accounting for a significant portion of the variance (R = 0.836, predictive value = 63.9%). This strong correlation and the significant predictive power (F1/407 = 463.719; p-value = .000) suggest that equipping lecturers with digital competencies and integrating AI tools into teaching practices can substantially improve student learning in online environments. These results underscore the need for universities to invest in continuous digital training for lecturers and incorporate AI-based educational tools to optimize learning experiences and outcomes. Supporting the above findings, Oguguo et al. (2020) found that digital literacy among lecturers significantly enhances student engagement and learning outcomes in Nigerian universities, while Obialo and Ojo (2021) reported that the use of AI in education positively impacts students' academic performance. However, a contrasting study by Eze et al. (2022) revealed minimal impact of lecturers' digital skills on online learning outcomes, which could be due to the study's focus on rural universities with limited access to technology and digital infrastructure, highlighting the importance of context in assessing the effectiveness of digital skills in education.

Conclusion

The findings revealed that lecturers' digital literacy skills and application of artificial intelligence not only significantly contribute individually to enhancing the quality of online education but also have a combined effect that strongly predicts students' online learning outcomes and overall academic performance. This underlines the importance of investing in digital skill development and AI tools to improve online learning experiences and outcomes in higher education institutions. The study however concluded that lecturers' digital skills and the integration of artificial intelligence are critical factors in predicting online learning outcomes among undergraduates in federal universities in South-East, Nigeria.

Recommendations

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

1. School Management should invest in robust digital infrastructure, ensuring reliable internet access, up-to-date software, and necessary hardware to support online learning platforms. They should also embark on regular maintenance and upgrades that will help sustain the quality of online education.
2. Lecturers should engage in ongoing training and professional development programs focused on enhancing digital skills and the effective integration of artificial intelligence tools in teaching. This will improve their ability to deliver high-quality online instruction.
3. Policy makers should develop and implement policies that promote the use of digital tools and artificial intelligence in education. This should include funding for technological resources, incentives for educators to upgrade their skills, and guidelines for integrating AI into the curriculum.
4. Students should be encouraged to develop their digital literacy skills to fully engage with online learning platforms through workshops or courses that help students become proficient in using digital tools and understanding AI applications in their studies.
5. The society, including parents and community organizations, should be made aware of the benefits of digital and AI-driven education. By supporting initiatives that bridge the digital divide, they can contribute to creating an environment where all students have access to quality online learning resources.

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