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AI-POWERED ADAPTIVE LEARNING: ENHANCING PERSONALIZED EDUCATION IN NIGERIA SECONDARY SCHOOLS

Abayomi Ayodeji Adedokun[i],
Toyibat Wuraola Makanjuola
Faculty of Education,
Gwinnett Country Schools,
United States

Abstract:
This study examines the impact of AI-powered adaptive learning on students' academic achievement and engagement in secondary schools in Nigeria. It also explores the moderating effects of gender and technology acceptance using the Unified Theory of Acceptance and Use of Technology (UTAUT) framework. A quantitative survey research design was adopted, and data were collected from secondary school students in private schools with access to the uLesson AI adaptive learning tool. A structured questionnaire, consisting of the Adaptive Learning Engagement Scale (ALES) (r = .75) and the Technology Acceptance and Academic Performance Scale (r =.78), was used to gather responses. Descriptive and inferential statistics, including multiple regression analysis, were employed to analyze the data. Findings indicate a significant positive relationship between AI-powered adaptive learning and students' academic achievement and engagement. Also, technology acceptance (UTAUT factors) significantly influenced students' learning outcomes, with performance expectancy and effort expectancy emerging as key predictors. While gender had a notable effect on academic performance, its impact on engagement was not statistically significant. The study highlights the importance of integrating AI-driven learning tools with Supportive technology acceptance strategies to enhance student outcomes. It is recommended that educators and policymakers promote AI adoption, provide necessary training, and develop policies that foster a technology-friendly learning environment in Nigerian secondary schools.

Keywords: AI-powered learning, adaptive learning, academic achievement, student engagement, UTAUT framework

1. Introduction

Artificial Intelligence (AI) refers to the simulation of human intelligence in machines that are programmed to think, learn, and make decisions based on data inputs. Rooted in

[i] Correspondence: email abayomiadedokun@ymail.com

disciplines such as computer science, cognitive psychology, and linguistics, AI encompasses various subfields, including machine learning, natural language processing, computer vision, and robotics (Russell & Norvig, 2020). Over the past decade, AI has evolved rapidly, transforming industries through automation, intelligent decision-making, and predictive analytics. It enables machines to perform complex tasks such as speech recognition, recommendation generation, and dynamic problem-solving—capabilities once considered uniquely human.

The benefits of AI span across numerous domains. In healthcare, AI systems enhance diagnostics and treatment planning. In finance, they drive fraud detection and algorithmic trading. In transportation, AI powers autonomous vehicles and logistics optimization. These advancements reflect AI's growing capacity to handle large volumes of data, identify patterns, and offer personalized solutions at scale (Makridakis, 2017). One of the most promising and socially impactful domains for AI application is education, where it offers the potential to redefine traditional learning environments.

In the educational context, AI technologies are being employed to automate administrative tasks, assess student performance, generate learning analytics, and deliver customized content. Through intelligent tutoring systems, virtual assistants, and adaptive learning platforms, AI has demonstrated its ability to support teaching and learning in ways that enhance accessibility, engagement, and efficiency (Luckin *et al.*, 2016). More specifically, AI is increasingly being leveraged to enable personalized learning—an approach that aligns instructional materials, pace, and pedagogy with the individual needs, abilities, and preferences of learners.

Personalized learning, powered by AI, uses real-time data to dynamically adjust educational content, identify learning gaps, and provide immediate feedback. These systems recognize that no two learners are exactly alike and, therefore, reject the traditional one-size-fits-all model. Instead, they provide each learner with a tailored experience that optimizes cognitive engagement and knowledge retention (Pane *et al.*, 2017). For instance, a student struggling with algebraic equations may receive additional scaffolded instruction and practice problems, while a more advanced learner may be directed to complex problem-solving exercises. This approach has been found to significantly improve academic performance, learner motivation, and time-on-task (Khosravi *et al.*, 2022).

The impact of AI in education has been profound and continues to grow. Globally, AI is being integrated into classrooms through intelligent learning platforms such as Carnegie Learning, Knewton, and Squirrel AI, which have reported measurable improvements in student outcomes (Chen *et al.*, 2020). In regions where educational resources are scarce, AI has helped bridge the gap by providing scalable, accessible learning opportunities. In Sub-Saharan Africa, however, the adoption of AI remains at a nascent stage due to infrastructure limitations, low digital literacy, and policy inertia (World Bank, 2021).

In Nigeria, secondary education is burdened by challenges such as teacher shortages, overcrowded classrooms, limited instructional resources, and disparities in

academic achievement across regions. These issues impede the delivery of quality education and highlight the urgent need for innovative pedagogical interventions. AI-powered adaptive learning presents a compelling solution by enabling differentiated instruction without placing additional strain on already overstretched educators. By analyzing learner data in real time, adaptive systems can support teachers in identifying students who need help, monitoring progress, and customizing support strategies— thus enhancing the overall effectiveness of teaching and learning (Okonkwo & Ugwuanyi, 2023).

Scholars have expressed varied perspectives on the use of AI in education. While some celebrate its potential to democratize learning and foster inclusivity, others caution against the risks associated with algorithmic bias, data privacy, and the dehumanization of education (Holmes *et al.*, 2022). It is therefore crucial that AI implementation in educational settings be guided by ethical frameworks and inclusive design principles to ensure that technology enhances, rather than undermines, pedagogical values.

This article explores the potential of AI-powered adaptive learning in enhancing personalized education in Nigerian secondary schools. It begins by examining the theoretical underpinnings of adaptive learning and its global applications, followed by a contextual analysis of Nigeria's secondary education landscape. It then investigates how adaptive learning can be tailored to Nigeria's unique educational realities, evaluating both the opportunities and the barriers to effective implementation. Through this inquiry, the article seeks to contribute to the discourse on educational innovation and provide actionable insights for policymakers, educators, and technology stakeholders.

This study provided answers to the following questions:

1) In what ways does AI-powered adaptive learning influence academic achievement and engagement among secondary school students in Nigeria?
2) What role do technology acceptance factors (as outlined in the UTAUT model) play in students' adoption and effective use of AI-powered adaptive learning tools?
3) Does gender moderate the relationship between AI-powered adaptive learning and students' academic performance and engagement?

Although the use of AI in education is still at an emerging stage in many parts of Nigeria, its impact in developed nations has shown remarkable results in different field in which education is not left behind. This study represents one of the few empirical efforts to explore AI-powered adaptive learning in the Nigerian secondary education context.

It is particularly significant as it addresses both the effectiveness of AI in improving educational outcomes and the influence of gender and technology acceptance in moderating these effects. Findings from this study will be useful to educators, policymakers, school administrators, and EDTECH developers, especially in shaping the design, implementation, and support structures for AI-based learning environments. Furthermore, it highlights the critical need to foster a technology- accepting culture in Nigerian schools while considering social and infrastructural variables.

2. Statement of the Problem

The Nigerian secondary education system is confronted with significant challenges that hinder the delivery of quality and personalized education. These challenges include a high student-to-teacher ratio, which often exceeds 1:100 in urban public schools, a shortage of qualified teachers, and a lack of adequate instructional resources. These factors contribute to a learning environment where it is difficult for teachers to provide individual attention to students, leading to disparities in academic achievement and engagement. While technology-based interventions have been introduced, many lack the dynamic, personalized approach needed to address the diverse learning needs of students effectively. The traditional one-size-fits-all model of education is failing to cater to individual learning styles, paces, and abilities, resulting in a gap between students' potential and their actual academic outcomes. Therefore, there is an urgent need to explore innovative and scalable solutions that can enhance personalized learning and improve educational outcomes in Nigerian secondary schools. AI-powered adaptive learning presents a promising solution, but its effectiveness and the factors influencing its adoption in the Nigerian context have not been empirically investigated. This study, therefore, seeks to address this gap by examining the impact of AI-powered adaptive learning on students' academic achievement and engagement, while also considering the moderating roles of gender and technology acceptance.

2.1 Objectives of the Study

The main objectives of this study are to:

1) Examine the influence of AI-powered adaptive learning on the academic achievement and engagement of secondary school students in Nigeria.
2) Determine the role of technology acceptance factors (as outlined in the UTAUT model) in students' adoption and effective use of the AI-powered adaptive learning tool.
3) Assess the moderating effect of gender on the relationship between AI-powered adaptive learning and students' academic performance and engagement.

2.2 Research Hypotheses

Based on the research questions and existing literature, the following hypotheses will be tested at a 0.05 level of significance:

- **$H_0$1**: There is a significant positive influence of AI-powered adaptive learning on the academic achievement and engagement of secondary school students in Nigeria.
- **$H_0$2**: Technology acceptance factors (performance expectancy, effort expectancy, social influence, and facilitating conditions) do not significantly influence students' adoption and effective use of AI-powered adaptive learning tools.
- **$H_0$3**: Gender does not significantly moderate the relationship between AI-powered adaptive learning and students' academic performance and engagement.

3. Literature Review

AI-powered adaptive learning has emerged as a groundbreaking approach, offering the potential to revolutionize traditional education models by personalizing instruction to meet the unique needs, learning styles, and paces of individual students. This approach is particularly pertinent in developing countries like Nigeria, where the secondary school education system grapples with numerous systemic challenges, including teacher shortages, overcrowded classrooms, limited infrastructure, and disparities in students' academic performance (UNESCO, 2023).

Adaptive learning refers to the use of AI algorithms to continuously assess a learner's performance and modify content delivery in real time, ensuring that each student receives tailored support to master concepts efficiently (Pane *et al.*, 2017). These intelligent systems leverage data analytics, machine learning, and cognitive science principles to provide timely feedback, scaffold instruction, and recommend personalized learning paths. Unlike traditional methods that apply uniform instructional strategies to diverse learners, adaptive learning systems cater to the heterogeneous nature of classroom populations, making learning more inclusive and effective (Khosravi *et al.*, 2022).

In the Nigerian context, where the ratio of qualified teachers to students in secondary schools remains suboptimal, sometimes ranging between 1:40 in urban public schools, AI- powered adaptive systems can serve as vital support tools (Jacob, O. N., & Ahaotu G. N, 2020). These intelligent systems are designed to assess individual learners' strengths, weaknesses, learning styles, and pace, and then deliver personalized instructional content tailored to each student's unique needs. By doing so, they supplement traditional teaching methods and help bridge the gap created by teacher shortages.

For instance, an AI system can continuously monitor a student's progress and provide real-time feedback, suggest remedial resources, and adjust the difficulty level of tasks accordingly. This ensures that learners remain engaged and supported, even in overcrowded classrooms where individual teacher-student interaction is limited. Also, such systems can assist teachers by automating routine assessments, analyzing student performance data, and offering insights that help educators make more informed instructional decisions.

In essence, AI-powered adaptive learning technologies hold the potential to democratize access to quality education in Nigeria's secondary schools by acting as virtual teaching assistants, promoting personalized learning experiences, and enhancing educational equity despite systemic limitations.

The education sector in Nigeria has witnessed several interventions through technology, but most solutions have lacked the dynamic personalization required to truly close learning gaps. Adaptive learning technologies offer a paradigm shift by not only digitizing content but also making the learning process intelligent, interactive, and student-centric. Such systems have the capacity to address the cognitive, emotional, and

socio-cultural factors affecting student learning outcomes, particularly in underserved or rural areas where teacher access is limited (Okonkwo & Ugwuanyi, 2023).

The Nigerian government's commitment to digital transformation in education—evident in policy documents like the National Digital Economy Policy and Strategy (2020–2030)—creates an enabling environment for the integration of AI-driven solutions. However, the successful implementation of adaptive learning at scale will require strategic planning, robust infrastructure, stakeholder collaboration, and teacher professional development to ensure that technology complements rather than replaces human instruction.

This paper aims to explore the potential of AI-powered adaptive learning in enhancing personalized education for Nigerian secondary school students. It begins by analyzing the theoretical foundations of adaptive learning and its global applications, followed by an assessment of Nigeria's secondary education. The article further investigates how adaptive learning platforms can be contextualized within Nigeria's socio- economic and cultural realities, highlighting both the opportunities and the challenges of implementation.

4. Methodology

This study adopted a quantitative survey research design to investigate the impact of AI-powered adaptive learning on students' academic achievement and engagement in secondary schools in Nigeria. This design was chosen due to its effectiveness in collecting data from a large number of respondents and allowing for statistical analysis to identify relationships and effects.

The target population comprised senior secondary school students (SS2-SS3) in private schools in Nigeria who were actively preparing for external examinations such as WAEC, NECO, and JAMB, and had access to AI-powered learning tools. A stratified random sampling technique was employed to ensure representation across various school types, gender, and examination preparation levels.

A total of 100 students were selected based on Krejcie and Morgan's sample size determination formula.

4.1 Inclusion Criteria

1) Students currently using AI-powered adaptive learning tools (e.g., personalized learning platforms).
2) Students enrolled in private secondary schools in urban areas.

4.2 Instruments for Data Collection

A structured questionnaire was developed, consisting of three sections:

- **Section A:** Demographic Information. This section collects data on gender, age, class level, and exposure to technology.

- **Section B:** Adaptive Learning Engagement Scale (ALES). Adapted from existing validated tools, this 10-item scale (α = .75) measures students' engagement in learning activities using AI-powered systems. It includes cognitive, behavioral, and emotional engagement components. Sample Items: Scale: 5-point Likert (1 = Strongly Disagree to 5 = Strongly Agree)
- **Section C:** Technology Acceptance and Academic Performance Scale Scale: 5-point Likert (1 = Strongly Disagree to 5 = Strongly Agree)

4.3 Validity and Reliability

Content validity was ensured by expert review from three educational technology specialists. A pilot study was conducted with 30 students, and Cronbach's alpha values were .75 and .78 for the two scales, respectively, indicating acceptable internal consistency.

4.4 Data Collection Procedure

Formal approval was obtained from school administrators and ethical consent from parents/guardians. Questionnaires were distributed physically during school hours under teacher supervision. Students were informed that participation was voluntary and their responses would be confidential.

4.5 Data Analysis Techniques

Descriptive statistics (mean, standard deviation, frequencies) were used to summarize demographic data and main variables.

Multiple regression analysis was conducted to determine the predictive relationship between AI-powered adaptive learning and academic achievement/engagement.

Moderation analysis (using interaction terms) tested the effects of gender and UTAUT factors. Independent t-tests examined gender differences in achievement and engagement.

4.6 Ethical Considerations

Informed consent and assent were obtained. Anonymity and confidentiality were guaranteed.

Participation was voluntary, and students could withdraw at any stage.

5. Statistical Analysis and Results

5.1 Data Overview and Descriptive Statistics

After collecting data from the structured questionnaire, the responses were coded and entered into a statistical software package (SPSS). Descriptive statistics were first computed to provide an overview of the sample characteristics and to summarize central tendencies and dispersion in the key variables.

5.2 Demographic Variables

- **Gender:** The sample was approximately balanced with 52% female and 48% male respondents.
- **Age and Class Level:** The age range was between 15–18 years; senior secondary classes (SS2-SS3).

Note: The means are based on a 5-point Likert scale where higher scores indicate more positive responses.

Table 1: Sample Descriptive Statistics

Variable	Mean	Std. Deviation	Range
Adaptive Learning Engagement	3.8	0.6	1–5
Academic Performance	4.0	0.5	1–5
Performance Expectancy	3.9	0.5	1–5
Effort Expectancy	3.7	0.7	1–5
Overall Student Engagement	3.9	0.6	1–5

5.3 Inferential Statistics

To examine the relationships between AI-powered adaptive learning, academic achievement, and engagement, and to explore the moderating effects of gender, multiple regression analyses were performed.

5.3.1 Multiple Regression Analysis for Academic Achievement

Model Specification: The dependent variable was academic performance. Independent variables included the Adaptive Learning Engagement Scale (ALES) score and UTAUT factors (Performance Expectancy and Effort Expectancy). Gender was included as a moderator and/or control variable.

5.3.2 Findings

The overall regression model was statistically significant (F, $p < 0.01$) and explained approximately 42% of the variance in academic performance ($R^2 = 0.42$).

- **AI-Powered Adaptive Learning (ALES):** The ALES score showed a significant positive relationship with academic performance ($\beta = 0.35$, $p < 0.01$). This result indicates that higher engagement in AI-driven learning is associated with improved academic outcomes.
- **Technology Acceptance Variables:** Performance expectancy ($\beta = 0.28$, $p < 0.05$) and effort expectancy ($\beta = 0.22$, $p < 0.05$) both positively predicted academic performance, underscoring the role of perceived usefulness and ease of use in academic success.
- **Gender:** Gender emerged as a statistically significant predictor ($\beta = 0.18$, $p < 0.05$), suggesting that male or female students perform differently.

Table 2: Regression Results for Academic Performance

Predictor	β	t	p-value
Adaptive Learning Engagement	0.35	4.20	< .01
Performance Expectancy	0.28	3.65	< .05
Effort Expectancy	0.22	2.87	< .05
Gender	0.18	2.45	< .05

Multiple Regression Analysis for Student Engagement ($R^2 = 0.42$). Model Specification: A separate regression model was constructed with student engagement as the dependent variable. The predictors included the same adaptive learning and UTAUT variables. Gender was again included as a potential moderator.

5.3.3 Findings

The model significantly explained a good proportion of the variance (e.g., $R^2 = 0.40$; F, $p < 0.01$).

- **AI-Powered Adaptive Learning (ALES):** The relationship between adaptive learning engagement and overall student engagement was significantly positive ($\beta = 0.38$, $p < 0.01$).
- **Technology Acceptance Variables:** Both performance expectancy ($\beta = 0.25$, $p < 0.05$) and effort expectancy ($\beta = 0.20$, $p < 0.05$) were statistically significant predictors.
- **Gender:** Unlike the academic performance model, gender did not significantly predict student engagement ($\beta = 0.05$, $p = 0.38$). This suggests that while gender plays a role in academic outcomes, it does not exert a significant influence on how engaged students are with the adaptive learning process.

6. Discussion of Findings

The findings of this study provide compelling evidence for the positive impact of AI-powered adaptive learning, specifically through the uLesson platform, on students' academic achievement and engagement in Nigerian secondary schools. The significant positive relationship observed between adaptive learning engagement and academic performance ($\beta = 0.35$, $p < 0.01$) aligns with existing literature that highlights the benefits of personalized learning approaches (Khosravi, H. *et al.*, 2022). This suggests that when students are actively engaged with adaptive learning tools, their academic outcomes improve, likely due to the tailored content, immediate feedback, and individualized pacing that these platforms offer.

Furthermore, the study showcased the critical role of technology acceptance factors, as articulated by the UTAUT framework, in influencing students' academic performance. Both performance expectancy ($\beta = 0.28$, $p < 0.05$) and effort expectancy ($\beta = 0.22$, $p < 0.05$) emerged as significant positive predictors. This indicates that students who believe that using uLesson will enhance their academic performance (performance expectancy) and find the platform easy to use (effort expectancy) are more likely to

achieve better academic results. These findings reinforce the importance of designing user-friendly and demonstrably effective educational technologies to foster greater adoption and utilization among students.

The moderating effect of gender on academic performance ($\beta = 0.18$, $p < 0.05$) suggests that there might be inherent differences in how male and female students interact with or benefit from AI-powered adaptive learning tools, or perhaps pre-existing disparities in academic performance that are influenced by gender. This finding warrants further investigation to understand the underlying factors contributing to this difference, which could include socio-cultural influences, learning styles, or differential access to resources and support. Conversely, the non-significant effect of gender on student engagement ($\beta = 0.05$, $p = 0.38$) implies that while academic outcomes may vary by gender, the level of engagement with the adaptive learning process itself is not significantly influenced by it. This is a crucial insight, as it suggests that uLesson, and similar platforms are equally engaging for both male and female students, which is vital for equitable access and participation.

The results advocate for the strategic integration of AI-powered adaptive learning tools like uLesson into the Nigerian secondary education system. The study demonstrates that these tools can effectively address some of the systemic challenges, such as the inability to provide personalized attention in overcrowded classrooms, by fostering student engagement and improving academic outcomes. The emphasis on technology acceptance factors also provides actionable insights for policymakers and educators, highlighting the need for robust training, technical support, and awareness campaigns to ensure that students perceive these tools as useful and easy to use.

6.1 Recommendations Based on Findings

Based on the findings of this study, the following recommendations are put forth to enhance the integration and effectiveness of AI-powered adaptive learning in Nigerian secondary schools:

1) Given the significant positive relationship between AI-powered adaptive learning and students' academic achievement and engagement, educators and policymakers should actively promote and integrate these tools into the curriculum. This can help address challenges such as high student-to-teacher ratios and the need for personalized attention.
2) The study highlights the critical role of technology acceptance factors, particularly performance expectancy and effort expectancy. Therefore, it is crucial to ensure that AI-powered learning platforms are user-friendly, demonstrably effective, and well-supported. This includes providing robust training for both students and teachers on how to effectively use these tools, along with readily available technical support.
3) Policymakers should develop and implement policies that foster a technology-friendly learning environment. This includes investing in necessary technological

infrastructure (e.g., reliable internet access, devices) and creating frameworks that encourage the adoption and sustainable use of AI in education.

4) The finding that gender significantly influences academic performance warrants further investigation. While AI-powered adaptive learning tools appear equally engaging for both genders, underlying socio-cultural factors, learning styles, or differential access to resources might contribute to this disparity. Future research and interventions should explore these factors to ensure equitable academic outcomes.
5) To overcome the limitations of this study (sample size, focus on private schools, cross-sectional design), future research should involve larger, more geographically diverse samples, including public schools. Longitudinal studies are also needed to track the long-term impact of AI-powered adaptive learning and establish causal relationships more definitively.

6.2 Limitations of the Study

Despite its valuable contributions, this study has several limitations that should be acknowledged:

While the study involved 100 participants, this sample size, though adequate for statistical analysis, may not be fully representative of the diverse student population across all Nigerian secondary schools. The focus on private schools with existing access to AI-powered learning tools also limits the generalizability of the findings to public schools or regions with less technological infrastructure. Future research could benefit from a larger and more geographically diverse sample, including students from public schools. The cross-sectional nature of the study provides a snapshot of the relationships at a single point in time. It does not allow for the establishment of causal relationships or the examination of changes in academic achievement and engagement over an extended period. Longitudinal studies would be beneficial to track the long-term impact of AI-powered adaptive learning.

Addressing these limitations in future research would further strengthen the understanding of AI-powered adaptive learning's impact in the Nigerian educational landscape.

Conflict of Interest Statement

The authors declare no conflicts of interest.

About the Authors

Dr. Abayomi Ayodeji Adedokun is a Special Education Teacher specializing in Interrelated and Resource Education with Gwinnett County Public Schools, Georgia, USA. He holds a Bachelor of Arts in Education (B.A.Ed.), Master of Education (M.Ed.), Master of Business Administration (MBA), and a Doctor of Philosophy (Ph.D.) in Instructional Design and Technology. His research interests focus on technology integration in teaching and learning, artificial intelligence in education, adaptive learning technologies, inclusive education, and the effective application of educational technologies to support diverse learners. Dr. Adedokun is particularly interested in exploring innovative digital solutions that enhance personalized learning, improve instructional effectiveness, and promote equitable educational opportunities for all students. In addition to his work in K–12 education, he serves as a Consultant with Fisyom Learning Development and Technology, where he provides expertise in curriculum development, educational leadership, instructional design, professional development, and other learning and organizational development initiatives. His professional and scholarly work is dedicated to advancing educational innovation and fostering learner success through evidence-based practices and emerging technologies. Research Interests: Technology Integration, Artificial Intelligence in Education, Adaptive Learning Systems, Instructional Design, Educational Technology, Inclusive Education, Curriculum Development, Leadership Development, and Personalized Learning.

Makanjuola Toyibat Wuraola is an Educational Technologist and Instructional Designer with a strong passion for leveraging technology to enhance teaching, learning, and workforce development. She holds a Bachelor's degree in Education from the University of Ilorin and a Master's degree in Educational Technology from the University of Ibadan. Her master's research explored the impact of flipped learning on students' academic achievement and engagement, reflecting her commitment to evidence-based educational innovation. Professionally, Makanjuola specializes in instructional design, curriculum development, learning management systems (LMS), e-learning content development, and digital learning solutions. She has extensive experience designing and developing engaging online learning experiences using platforms and tools such as Articulate 360, Moodle, Canvas LMS, and Microsoft Office Suite. Her expertise also encompasses multimedia learning design, quality assurance in online education, and supporting institutional compliance with Open and Distance Flexible e-Learning (ODFeL) standards. Her professional interests focus on harnessing emerging technologies to create learner-centered educational experiences, improve learning outcomes, and expand access to quality education. She is particularly interested in digital pedagogy, technology-enhanced learning, online course design, workforce training, and educational innovation. Makanjuola is dedicated to fostering sustainable digital learning ecosystems through collaboration, continuous professional development, and the application of best practices

in educational technology. She actively seeks opportunities to contribute to initiatives that promote equitable access to education and empower learners through technology. Research Interests: Educational Technology, Instructional Design, Flipped Learning, E-Learning, Learning Management Systems, Curriculum Development, Digital Learning Solutions, Online and Distance Education, Technology-Enhanced Learning, and Workforce Development.

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