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AI-Driven Personalized Learning Tools as Catalysts of Digital Transformation in TVET education: Exploring Digital Natives' Experiences

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Research Article

Keywords: AI-driven learning, Digital natives, Adaptive learning systems, Networking education, Digital inclusion, TVET

Posted Date: May 28th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-9692842/v1

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Additional Declarations: The authors declare no competing interests.

Abstract

Purpose:

Artificial intelligence (AI) is increasingly transforming education by supporting personalized learning tailored to individual student needs. However, despite widespread global adoption, the use of AI-powered personalized learning tools among digital natives in technical and vocational education and training (TVET) institutions in developing regions has not been sufficiently examined. This study investigates the experiences of digital natives with AI-driven personalized learning tools and their role in supporting digital transformation in learning.

Methods:

The study employed a descriptive survey design. The data were collected through a structured questionnaire distributed via Google Forms. The instrument was validated by experts, and a reliability coefficient of 0.81 was obtained using Cronbach's alpha. The data analysis involved calculating the mean and standard deviation, with a cutoff mean of 2.5, while factor loading was used to determine the validity of the measured constructs.

Results:

The findings showed that AI-based personalized learning enhances student engagement, promotes interaction, and improves motivation by providing adaptive content and timely feedback. Nonetheless, challenges such as low digital literacy levels, high implementation costs, inadequate institutional funding, and resistance from educators were identified as major barriers to effective adoption.

Conclusion:

The study concludes that AI-powered personalized learning holds strong potential for improving learning outcomes in TVET among digital native-born institutions. To achieve this, there is a need to address existing challenges through targeted investments and capacity building. It is recommended that educators promote the responsible use of AI tools, while continuous digital literacy training should be provided for both staff and students to support inclusive and technology-driven learning environments.

Introduction

Artificial intelligence (AI) has emerged as a transformative force in the 21st century, fundamentally reshaping the educational landscape and the ways in which learners engage with knowledge. It offers innovative solutions that improve teaching and learning processes through adaptive, data-driven, and learner-centered approaches (Chassignol et al., 2018). By integrating large datasets, algorithms, and computational intelligence, AI can solve complex educational problems related to practical courses such as computer networking and personalize learning experiences (Gasser & Almeida, 2017). AI plays a central role in intelligent tutoring systems, adaptive learning platforms, and automated assessment tools

that tailor instruction to learners' individual needs. These systems dynamically adjust learning paths, generate networking images, identify areas for improvement, provide real-time feedback, and promote self-directed learning and academic performance (Lin et al., 2023). AI-powered learning tools embody Knowles' (1984) principles, which emphasize allowing learners to control what, when, and how they learn while receiving adaptive feedback and support. Networking courses are designed to equip learners with the competencies and skills required to design, implement, and manage computer network environments effectively (Forouzan, 2017). These courses typically cover fundamental topics such as network foundations, IP addressing, subnetting, routing and switching, network security and wireless technologies, as well as software-defined networking (SDN) and cloud computing (Forouzan, 2017; Kurose & Ross, 2021).

As a practical-oriented course in TVET that can be taught even with limited instructional support, AI-powered personalized learning facilitates the creation of high-quality instructional materials that may not be physically available to enhance learning and formative assessments (Cacicio & Riggs, 2023). Simulations, virtual laboratories, and hands-on assessments are often incorporated to deepen digital natives' understanding of networking concepts and prepare them for real-world networking challenges (Panko & Panko, 2021). For instance, when learning how to configure IP addresses, AI-powered tools guide learners through each step of the process when properly prompted. Therefore, the integration of AI-driven personalized learning tools in Technical and Vocational Education and Training (TVET) education represents a key step toward digital transformation in higher education, fostering innovation in pedagogy, assessment, and digital natives' engagement in lessons. TVET is a subdivision of education that comprises continuing professional development and work-based learning (UNESCO, 2016). It provides digital natives with 21st-century digital skills such as critical thinking, problem solving, and artificial intelligence (AI) knowledge (Razali, et al, 2023).

Digital natives are students who were born after the widespread adoption of digital technology; they are inherently active users of technology and technology savvy. Students born after 1981 are also referred to as digital natives (Prensky 2001). Therefore, the majority of the current students studying computer networking courses can be referred to as digital natives. This group of students is expected to have high access to the internet and use it extensively for learning, work, and leisure. However, the adoption of AI-powered personalized learning in tertiary education still raises concerns related to equity, access, and readiness to adopt in learning. Learners from rural or low-income areas such as Nigeria often face barriers such as financial constraints in the procurement of AI tools, lack of digital devices, and limited exposure or access to AI-based personalized tools (Ubiminds, 2024; Selwyn, 2019). These disparities risk widening the existing digital divide and may hinder the realization of AI's transformative potential in higher education, especially in developing regions (Ogunode et al., 2023). It is unfortunate to see educators expressing skepticism about the reliability of AI technologies or fear that such systems could replace traditional teaching roles (Clark et al., 2019). This, therefore, results in low adoption of the tool for teaching and learning.

Against this backdrop, this study aims to examine digital natives' perceptions of the impact of AI-driven personalized learning tools as catalysts for digital transformation in TVET education. Specifically, this study seeks to identify the perceptions of digital native learners on the adoption of AI-driven personalized learning, the perceived impact of AI-driven personalized learning tools on digital natives' academic achievement and engagement and to identify the possible challenges that hinder the effective adoption and utilization of AI-driven personalized learning tools in learning networking courses.

Research Questions

To achieve the stated objectives, the following research questions will guide the study:

1. What are the perceptions of students of the adoption of AI-driven personalized learning tools in computer networking courses?
2. How do AI-driven personalized learning tools influence students' academic achievement and learning engagement?
3. What are the challenges that hinder the effective adoption of AI-driven personalized learning tools in tertiary institutions?

Research Hypotheses

The following null hypotheses will be tested at the 0.05 level of significance:

- **H_{01}:** There was no significant difference in the mean responses of male and female students regarding their perceptions of the adoption of AI-driven personalized learning tools in computer networking courses.
- **H_{02}:** There is no significant difference in the mean responses of male and female students regarding the perceived influence of AI-driven personalized learning tools on academic achievement.
- **H_{03}:** There was no significant difference in the mean responses of male and female students to the challenges that hinder the effective adoption of AI-driven personalized learning tools in tertiary institutions.

Literature review

AI-Powered Personalized Online Learning among Digital Natives

The integration of artificial intelligence into higher education is gradually changing pedagogical approaches, particularly in the aspect of electronic learning, by allowing unprecedented levels of personalization (Maghsudi et al., 2021). AI-powered personalized learning helps individuals adapt educational content and interactions to suit their unique needs, preferences, and pace (Jian, 2023). This adaptive approach goes beyond traditional, standardized instructional methods, thereby offering

dynamic learning pathways that address real-time student performance and engagement (Jian, 2023; Naseer et al., 2024). Moreover, more effective and meaningful educational experiences can be nurtured by allowing adaptive learning environments that adjust content, pacing, and instructional methods to each student's unique characteristics (Merino-Campos, 2025). Some examples of AI-powered personalized learning environments include intelligent tutoring systems such as Khanmigo, Mindjoy, and Edcafe AI; adaptive learning platforms such as 30Learning, Adaptemy Knewton and Safety Culture; and AI-driven feedback adaptive learning that dynamically adjusts to student progress and comprehension (Al-Zahrani & Alasmari, 2024; George & Wooden, 2023).

These tools can act as personal tutors, offering instant feedback, answering queries, and even suggesting supplementary resources based on the student's learning trajectory (Winkler & Söllner, 2018). Such AI-driven interventions are particularly relevant in the context of remote learning, where students might feel isolated due to the lack of face-to-face interactions. However, it becomes essential to understand the characteristics of the learners themselves, particularly those often described as "digital natives", a generation inherently immersed in technology from an early age, in which their expectations, learning preferences, and interactions with digital tools are shaped (Prensky, 2001; Christodoulou et al., 2018). The term "digital native" was introduced in 2001 by Marc Prensky, who referred to anyone born after 1980 *as Digital Natives (*Prensky, 2001). Although time stipulations between researchers for generations (Christodoulou E., Kalokairinou et al., 2018) such as *Generation Y* were born between 1981 and 1995 (Australian Bureau of Statistics [ABS] 2021), The *Net Generation was* born between 1980 and 2001 (Sherman 2009); *Google Generations were* born after 1993 (Rowlands et al.); and the current generation, *Generation Z.,* was born between 1996 and 2010.

Barriers to Effective Implementation of AI Personalized Learning in TVET Education

The implementation of personalized learning is not without challenges. Technological limitations often restrict access to necessary resources for both students and educators, leading to disparities in educational opportunities (Niknam & Thulasiraman, 2020). Resistance from educators who may be unfamiliar with or skeptical about new technologies can also hinder AI-powered personalized online learning adoption (Sharples, 2000). Ethical concerns related to data privacy also pose significant challenges, as personalized learning relies heavily on data collection and analysis, ensuring the security of sensitive information is paramount (Lockspeiser & Kaul, 2016). Socioeconomic factors also play a crucial role in determining students' ability to access the necessary technology for AI-driven learning. Students from lower socioeconomic backgrounds often lack access to devices such as laptops or tablets, as well as reliable internet connections (Selwyn, 2019). This lack of access not only limits their ability to engage with AI tools but also exacerbates existing educational inequalities.

Data privacy concerns represent another significant barrier to the effective implementation of AI in education. Educational institutions must navigate complex legal frameworks governing data privacy while striving to comply with regulations such as the Family Educational Rights and Privacy Act (FERPA) in the U.S. or the General Data Protection Regulation (GDPR) in Europe (Zawacki-Richter et al., 2019).

These regulatory compliance challenges can create obstacles for schools attempting to adopt AI technologies, as they must ensure that student data are collected, stored, and used ethically and securely. Attitudes toward AI usage in teaching practices can significantly influence how readily educators embrace these technologies. Some teachers may be skeptical about the effectiveness of AI tools or fear that they will replace traditional teaching methods (Clark et al., 2019). Addressing these barriers is essential for maximizing the potential benefits of these materials.

METHODOLOGY

A descriptive survey was used for this study, and a population of 2679 participants were obtained from six public universities in Southeast Nigeria (University of Nigeria, Nsukka, Nnamdi Azikiwe University, Ebonyi State University, Enugu State University of Science and Technology, Micheal Okpara University of Agriculture, and Chukwuemeka Odimegwu Ojukwu University), focusing on computers and robotics/compute education departments. Data on the population were obtained from the records available at the respective departments in each university at the time of this research—2024/2025 session. A sample size of 350 (200 males and 150 females) was used for this study. Their respective ages were taken into consideration to ensure that the study involved only digital native students. This was obtained using a multistage sampling technique. Data collection was facilitated through the utilization of a structured questionnaire that was structured into two distinct sections: Section A focuses on acquiring demographic information from each respondent, while Section B is intricately organized into three clusters containing 30 items, with each cluster dedicated to addressing specific research questions. A 4-point rating scale was utilized for the 10 items in clusters 1, 2, and 3, with the following designations: Strongly Agree (SA) = 4, Agree (A) = 3, Disagree (D) = 2, and Strongly Disagree (SD) = 1. After reliability and determination of the factor loading, two items were removed from clusters 1 and 2 each as a result of a load less than 0.5; this step left the item to 8 items each. For cluster 3, 3 items were removed, leaving only 7 items for the study. The instrument was also validated by three experts from the Department of Computer and Robotics Education and Computer Science, University of Nigeria Nsukka. The Cronbach's alpha test was applied to ascertain the reliability of the research instrument. Crongach Alpa was 0.81 for Cluster 1, 0.78 for Cluster 2, and 0.83 and 0.81 for Cluster 3, with an overall Crombach alpha of 0.81. Furthermore, the factor loadings of each item ranged from 0.564 0.940 for Cluster 1, 0.740 to 0.850 for Cluster 2 and 0.650 to 0.980 for Cluster 3. This indicates a closer connection and relationship between the constructs (see Tables 1, 2 and 3). The researcher administered the questionnaire via Google Forms in the institutional WhatsApp group with the assistance of class representatives and lecturers. The collected data were analyzed using the mean, standard deviation, factor loading and independent t tests with the aid of Statistical Package for Social Sciences (SPSS) version 25.

Results

Table 1

Students' perceptions of the adoption of AI-driven personalized learning tools in computer networking courses

S/N	Variables	Factor loading	$\overset{\smile}{\backslash \text{varvec}x}$	SD
AIA1	AI-driven tools make online learning more interactive and engaging	0.884	3.15	0.81
AIA2	AI-Powered personalized learning platforms motivate students to complete tasks and assignments,	0.898	3.26	0.82
AIA3	Personalized learning through AI helps me stay focused on my studies.	0.722	3.16	0.85
AIA4	AI personalized tools make learning more enjoyable and less boring.	0.857	3.21	0.77
AIA5	The feedback from AI personalized tools is quick and helps maintain my interest in the course.	0.651	2.91	0.92
AIA6	AI tools allow me to set learning goals, which enhances my performance.	0.702	3.09	0.94
AIA7	AI-driven learning platforms offer content tailored to my learning style and speed thereby helping in my academic achievements	0.908	3.15	0.91
AIA8	AI personalized help me actively participate in online discussions and collaborative activities.	0.640	3.07	0.83

Key: *AIA AI adoption, SD = standard deviation, x mean*

Table 2

How AI-driven personalized learning tools impact students' academic achievement and learning engagement in networking courses

S/N	Variables	Factor Loading	Mean	SD
PIAI1.	AI-powered personalized learning have improved my overall academic performance in online courses.	0.783	3.27	0.91
PIAI 2	AI-powered personalized learning has helped me grasp difficult concepts in my course of study	0.758	3.12	0.89
PIAI3	AI-powered personalized learning ability to provide feedback helps me identify areas where I need to improve academically.	0.775	3.15	0.90
PIAI4	This tool has helped me improve my problem-solving and critical thinking skills.	0.751	3.17	0.89
PIAI5	AI-powered personalized learning assessments provide accurate evaluations of my knowledge and skills.	0.775	3.05	0.78
PIAI6	It helps me to stay on track with my learning objectives, contributing positively to my academic success.	0.826	3.18	0.83
PIAI7	The recommendations usually made by AI-powered personalized learning tools are helpful in improving my understanding of the course material.	0.829	3.20	0.87
PIAI8	AI-driven learning platforms have positively impacted my exam preparation and performance.	0.753	3.06	0.90

Key: *PIAI: Perceived Influence of AI; SD = Standard Deviation*

Table 3

What are the challenges that hinder the effective adoption of AI-driven personalized learning tools in tertiary institutions?

S/N	Variables	Factor loading	$\overset{\smile}{\text{varvec}x}$	SD
CHAIA1	The high cost of AI-driven learning platforms makes them inaccessible for many students.	0.787	2.65	1.06
CHAIA2	Restriction of access to AI powered personalized learning platform	0.871	2.62	1.00
CHAIA3	Resistance from educators/lecturers	0.965	2.52	0.99
CHAIA4	Ethical concern relating to data privacy	0.686	2.62	0.92
CHAIA5	Lack of financial support for AI research and development impedes its implementation in online learning.	0.859	2.61	0.97
CHAIA6	Attitude of the institution toward adoption of this technology	0.808	3.00	1.03
CHAIA7	Digital literacy gap influences effective adoption of AI powered personalized learning tools	0.825	2.6.	1.00
	Cluster Mean			0.38

Key: *x= mean, CHAI A: Challenges that Hinders AI Adoption SD = Standard Deviation*

Table 4

Hypothesis 1: H_{01}: The mean responses of male and female students regarding their perceptions of the adoption of AI-driven personalized learning tools in computer networking courses.

Respondents	N	$\overset{\smile}{\text{varvec}X}$	SD	df	t	Level of sig.	Decision
Male	200	**3.87**	**1.18**	211	1.17	0.05	NS
Female	150	**3.7**	**1.06**				

Key: *SD=Standard deviation; df = Degree of freedom; X = Mean; NS = Not significant*

Table 5

H_{02}: **The mean responses of male and female students regarding the perceived influence of AI-driven personalized learning tools on academic achievement.**

Respondents	N	$\overset{\smile}{\text{varvec}X}$	SD	df	t	Level of sig.	Decision
Male	200	3.67	1.26	211	0.35	0.05	NS
Female	150	3.60	1.17				

Key: SD=Standard Deviation; df = Degree of Freedom; X = Mean; NS = Not significant (dup: abstract ?)

Table 6

H_{03}: **The mean responses of male and female students regarding the challenges that hinder the effective adoption of AI-driven personalized learning tools in tertiary institutions.**

Respondents	N	$\varvec{X}$	SD	df	t	Level of sig.	Decision
Male	100	3.67	1.26	211	0.35	0.05	NS
Female	150	3.60	1.17				

Key: SD=Standard Deviation; df = Degree of Freedom; X = Mean; NS = Not significant

Discussion

The findings of this study based on research question I (see Table 1) indicated that AI-driven tools make online learning more interactive and engaging and motivate digital natives to complete tasks and assignments in TVET education. Personalized learning through AI also helps them stay focused and engaged in studies and makes learning more enjoyable and less monotonous among learners. The findings further revealed, among others, that feedback from AI tools is quick and helps maintain interest in learning networking courses. These findings align with the results of Lunsford et al. (2018), who found that the use of online learning platforms significantly influences students' academic and professional trajectories by providing necessary support and resources. Similarly, An et al. (2023) found that both teachers' and students' behavioral intentions to use AI in the educational process are high as a result of the importance of AI in teaching and learning.

The findings in Table 2 reveal that digital natives perceive AI-powered personalized learning tools as having a positive influence on their academic achievement. There was an emphasis on improvements in performance, problem solving, and critical thinking skills—key competencies in learning. These findings correspond with the findings of Maghsudi et al. (2021) and Jian (2023), who noted that AI integration improves learning outcomes by providing adaptive feedback and individualized learning trials. The evidence supports the assertion that AI contributes meaningfully to learners' cognitive and metacognitive growth, promoting deeper engagement with learning materials.

However, despite these benefits, the findings for research question 3 (see Table 3) revealed numerous challenges, including institutional resistance, limited digital literacy among educators and learners, high costs of AI tools, and insufficient financial support for research and implementation. Additionally, concerns about ethical data use and privacy persist, mirroring findings from Zawacki-Richter et al.

(2019) and Ogunode et al. (2023), who identified institutional and infrastructural barriers as key impediments to effective AI adoption in education. The results from the hypothesis tests in Tables 4, 5, and 6 further strengthen these findings. The absence of significant gender differences across perceptions, influences, and challenges suggests that both male and female learners share similar experiences regarding AI-powered learning tools. This suggests that barriers to adoption are systemic rather than gender based and arise from institutional and contextual factors rather than demographic characteristics.

Implications of the Study

The findings of this study have important implications for TVET education practices and policy. The use of AI-powered learning tools was found to enhance learner engagement and motivation. Moreover, the barriers revealed by this study imply that successful AI integration in TVET education requires stronger institutional commitment to encouraging the adoption of artificial intelligence in teaching and the best strategy to close the gap in digital literacy among students. Addressing these issues is essential for ensuring that AI-supported learning environments are inclusive, sustainable, and responsive to the needs of digital natives in TVET education.

Conclusion and recommendation

This study sought to ascertain digital natives' perceptions of the impact of AI-powered personalized learning on academic achievement as well as possible challenges that might hinder its full adoption in the TVET education environment. The findings revealed that AI-powered personalized online learning tools significantly enhance students' engagement, motivation, and overall learning experience. The responses indicate that AI-driven tools increase the interactivity, enjoyment, and flexibility of online learning while providing timely feedback that sustains interest and commitment to academic tasks. Moreover, the study established that students generally view AI-based personalized learning as a positive influence on their academic achievement because it enhances problem-solving skills, critical thinking, and self-directed learning.

Despite these benefits, challenges such as institutional resistance, high costs of AI tools, limited financial support for AI research, a digital literacy gap, and inadequate technological readiness hinder the effective adoption of AI-powered personalized learning in TVET. While AI-powered tools have proven to be of immense potential for transforming online learning, their full impact depends on addressing contextual barriers and strengthening institutional and human capacities for sustainable adoption. Furthermore, the integration of AI into education represents a transformative shift toward inclusive, adaptive, and learner-centered learning environments. However, its success depends on sustained institutional commitment, capacity building, and ethical governance of AI technologies. Ensuring regular training and retraining on the effective use of AI-powered personalized learning will lead to considerable progress in adjusting the digital gap among digital natives in the TVET education environment.

Limitations of the Study

One major limitation of this study is that it focused solely on students' and educators' perceptions of AI-powered personalized online learning, excluding administrators whose perspectives could have provided a more holistic understanding of AI adoption challenges. Additionally, the sample size was limited to a specific region, and the findings may not fully represent the diverse experiences of students across Nigeria's higher education system.

Declarations

Ethics Approval Statement Ethical approval for this study was obtained from the Research Ethics Committee of University of Nigeria. Proper permission to conduct the study was also obtained from the relevant authorities of the participating institutions. The study was conducted in accordance with established ethical standards for research involving human participants.. Participant Consent Statement Informed consent was obtained from all participants prior to participation in the study. Participants were informed of the purpose of the study and were assured of confidentiality, anonymity, and their right to withdraw from the study at any time without any penalty.

References

1. Ajayi, O. (2023). The impact of personalized AI-driven learning paths on student engagement and academic performance at the University of Nigeria. *Journal of Educational Technology, 15*(2), 45–60.
2. An, D., Li, C., & Zhou, J. (2023). Teachers' and students' behavioral intentions toward artificial intelligence in education. *International Journal of Emerging Technologies in Learning, 18*(7), 1–15.
3. Australian Bureau of Statistics (ABS) 2021 Census Shows Millennials Overtaking Boomers. [(accessed on 15 January 2023)]; Available online: https://www.abs.gov.au/media-centre/media-releases/2021-census-shows-millennials-overtaking-boomers.
4. Baker, R. S., & Inventado, P. S. (2016). Educational data mining and learning analytics. In *Learning, design, and technology* (pp. 1–23). Springer.
5. Balfour, S. P. (2013). Assessing writing in MOOCs: Automated essay scoring and calibrated peer review. *Research & Practice in Assessment, 8*(1), 40–48.
6. Bandura, A. (1977). *Social learning theory.* Prentice Hall.
7. Benhamdi, M., Babouri, A., & Chiky, R. (2017). Personalized learning: A new approach for learning in higher education. *International Journal of Learning Management Systems, 5*(1), 12–20.
8. Bhatia, A. B., Mittal, K., Mahajan, R., & Whig, P. (2023). Computational psychometrics social analysis of learners in their learning behavior using AI algorithms. In *AI-enabled social robotics in human care services* (pp. 1–32). IGI Global.

9. Bicknell, J., Chen, Y., & Wu, Y. (2023). Artificial intelligence in education: A systematic literature review. *Computers & Education, 203*, 104120. https://doi.org/10.1016/j.compedu.2023.104120
10. Bu, Q. (2022). Ethical risks in integrating artificial intelligence into education and potential countermeasures. *Science Insights, 41*(1), 561–566.
11. Bundy, A. (2017). Preparing for the future of artificial intelligence. *AI & Society, 32*(2), 285–287. https://doi.org/10.1007/s00146-016-0685-0
12. Cacicio, T., & Riggs, L. (2023). Artificial intelligence and equitable access in adult education: Developing adaptive learning content. *Adult Learning, 34*(3), 145–158
13. Chan, C. K. Y., & Hu, W. (2023). Students' voices on generative AI: Perceptions, benefits, and challenges in higher education. *arXiv preprint.* https://arxiv.org/abs/2305.00290
14. Chassignol, M., Goksel, A., & Bozkurt, A. (2018). Artificial intelligence in education: A systematic review of the literature. *Journal of Educational Technology & Society, 21*(1), 1–15.
15. Chen, Y., Zhang, X., & Liu, J. (2022). The role of personalized AI-driven pathways in enhancing student engagement: A study at the University of Ilorin. *International Journal of Educational Research, 112*(1), 101–115. https://doi.org/10.1016/j.ijer.2022.101115
16. Christodoulou, E., Kalokairinou, A., Koukia, E., Intas, G., Apostolara, P., Daglas, A., & Zyga, S. (2015). The test-retest reliability and pilot testing of the" new technology and nursing students' learning styles" questionnaire. *International Journal of Caring Sciences*, *8*(3), 567.
17. Clark, D., Luckin, R., & Cukurova, M. (2019). The role of teachers in the age of artificial intelligence: A review of current research. *Journal of Educational Technology & Society, 22*(4), 1–13.
18. Costa, P., García, E., & Perrotta, C. (2023). Artificial intelligence in education: A systematic literature review. *Information Sciences, 610–611*, 123–145. https://doi.org/10.1016/j.ins.2022.11.021
19. Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly, 13*(3), 319–340.
20. Education Week. (2024, June). *AI and equity explained: A guide for K–12 schools.* https://www.edweek.org/technology/ai-and-equity-explained-a-guide-for-k-12-schools/2024/06
21. Fatima, A., Khonturaev, A., & Tapalova, A. (2023). Evaluating the impact of AI-personalized learning systems in higher education. *Journal of Artificial Intelligence, Machine Learning and Neural Network, 4*(5), 22–29. https://doi.org/10.55529/jaimlnn.45.19.29
22. Fazil, A. W., Hakimi, M., Shahidzay, A. K., & Hasas, A. (2024). Exploring the impact of AI technologies on student engagement and academic performance in university settings in Afghanistan. *RIGGS: Journal of Artificial Intelligence and Digital Business, 2*(2), 56–63.
23. Gasser, U., & Almeida, V. A. (2017). A layered model for AI governance. *IEEE internet Computing, 21*(6), 58–62.
24. Gleason, N. W. (2018). *Higher education in the era of the fourth industrial revolution* (p. 229). Springer Nature.

25. Groff, J. (2017). Components and strategies for personalized learning in higher education. *Education Sciences, 7*(3), 273–290.
26. Hatice, K. (2025). AI in adult vocational education: Adaptive pathways for flexible learners. *Journal of Continuing Education and Training, 39*(1), 23–36.
27. Hollander, J., Sabatini, J., Graesser, A., Greenberg, D., O'Reilly, T., & Frijters, J. (2023). Importance of learner characteristics in intelligent tutoring for adult literacy. *Discourse Processes, 60*(4–5), 397–409. https://doi.org/10.1080/0163853X.2023.2203543
28. Hsu, Y. C., & Ching, Y. H. (2023). Generative artificial intelligence in education, part two: International perspectives. *TechTrends, 67*(6), 885–890. https://doi.org/10.1007/s11528-023-00913-2
29. Hwang, G. J., Liang, J. C., Su, Y. S., & Chen, C. H. (2014). A systematic review of personalized learning: Theoretical frameworks and applications. *Educational Technology & Society, 17*(3), 1–20.
30. Jian, S. (2023). Personalized online learning and adaptive instruction: A case study of AI integration in higher education. *Journal of Educational Research and Practice, 13*(2), 55–67.
31. Knowles, M. S. (1984). *The adult learner: A neglected species* (3rd ed.). Gulf Publishing.
32. Kurose, J. F., & Ross, K. W. (2019). *Computer networking: A top-down approach* (pp. 607967-5). Harlow, England Boston: Pearson.
33. Lin, X., Wang, Y., & Li, J. (2023). Smart education with artificial intelligence: A meta-analysis of adaptive learning systems. *Journal of Educational Computing Research, 61*(4), 678–693.
34. Luckin, R., Holmes, W., Griffiths, M., & Forcier, L. B. (2016). *Intelligence unleashed: An argument for AI in education.* Pearson Education.
35. Maghsudi, S., Streicher, A., & Giunchiglia, F. (2021). Personalized learning through AI: Opportunities and challenges. *Computers & Education: Artificial Intelligence, 2*(1), 100028.
36. Mezirow, J. (1997). Transformative learning: Theory to practice. *New Directions for Adult and Continuing Education, 74*, 5–12.
37. Ogunode, N. J., Olofu, P. A., & Bassey, U. O. (2023). Barriers to effective usage of artificial intelligence in tertiary institutions in North-Central Nigeria. *Web of Semantics: Journal of Interdisciplinary Science, 1*(1), 38–43.
38. Panko, R. R., & Panko, J. L. (2015). *Business data networks and security* (pp. 145-147). Harlow, Essex: Pearson.
39. Prensky, M. (2001). Digital natives, digital immigrants part 2: Do they truly think differently?. *On the horizon*, *9*(6), 1-6.
40. Razali, S. S., Ismail, A., Yazid, F. M., Ahmad, M. F., Hashim, S., Rohanai, R., & Shafieek, M. S. M. (2023). TVET in the 21st century: Exploring multimedia elements in digital teaching and learning. *Journal of Technical Education and Training, 15*(1), 9–19.
41. Redecker, C., & Punie, Y. (2017). Digital competence of educators. *Edited by Yves Punie*.
42. Rowlands, I., Nicholas, D., Williams, P., Huntington, P., Fieldhouse, M., Gunter, B., ... & Tenopir, C. (2008, July). The Google generation: the information behavior of the researcher of the future. In *Aslib*

proceedings (Vol. 60, No. 4, pp. 290-310). Emerald Group Publishing Limited.

43. Selwyn, N. (2019). *Should robots replace teachers? AI and the future of education.* British Journal of Educational Technology, 50*(3), 1003–1012.
44. Sherman, R. O. (2009). Teaching the net set. *Journal of Nursing Education*, *48*(7), 359-360.
45. Sorrentino P (2018). The mystery of the digital natives' existence: Questioning the validity of the Prenskian metaphor. First Monday. 2018;23 doi: 10.5210/fm.v23i10.9434.
46. Stolterman, E., & Fors, A. C. (2004). Information technology and the good life. In *Information systems research: relevant theory and informed practice* (pp. 687-692). Boston, MA: Springer US.
47. Stolterman, E., & Fors, A. C. (2004). Information technology and the good life. In *Information systems research: relevant theory and informed practice* (pp. 687-692). Boston, MA: Springer US.
48. Tapscott, D. (1998). *Growing up digital* (Vol. 302). San Francisco: McGraw-Hill Companies.
49. Ubiminds. (2024). *Equity in artificial intelligence education.* https://www.ubiminds.com/equity-in-artificial-intelligence-education
50. UNESCO. (2021). Recommendations on the ethics of artificial intelligence. UNESCO.
51. Zawacki-Richter, O., Marzahn, C., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education: Where are we now and where do we go? *International Journal of Educational Technology in Higher Education, 16*(39), 1–20.