

ARTIFICIAL INTELLIGENCE AND ENTREPRENEURIAL VENTURE CREATION IN THE FOURTH INDUSTRIAL REVOLUTION: IMPLICATIONS FOR TVET INSTITUTIONS IN EPE, LAGOS

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Abstract

This study investigates the influence of Artificial Intelligence (AI) on entrepreneurial venture creation in the Fourth Industrial Revolution (4IR), and implications for Technical and Vocational Education and Training (TVET) institutions in Epe, Lagos State, Nigeria. Three purposes, research questions and hypotheses supported the study. A descriptive survey design was adopted for the study. The sample for the study was 204 (190 students and 14 lecturers) from TVET institutions and were selected through a stratified random sampling technique. Data were collected from the respondents using a structured questionnaire based on a five-point Likert scale. The data collected was analyzed using descriptive and regression analysis with SPSS version 25 software. The results revealed that AI competency integration in TVET curricula, AI-driven learning tools, and institutional readiness each have a positive and significant influence on entrepreneurial venture creation among students; therefore, the null hypotheses were rejected. The findings indicate that exposure to AI-related skills, access to intelligent learning platforms, and supportive institutional environments significantly enhance students' ability to identify opportunities and develop innovative business ventures. The study concludes that effective integration of AI in TVET is essential for fostering entrepreneurial capacity in the 4IR era. It recommends that TVET institutions prioritize AI-focused curriculum development, invest in digital infrastructure, and strengthen industry collaborations to equip students with relevant competencies for sustainable venture creation.

Keywords: Artificial intelligence, Entrepreneurial venture creation, 4IR, TVET, AI tools

Introduction

The global economy is undergoing rapid transformation driven by the Fourth Industrial Revolution (4IR), a phase characterized by the fusion of digital, biological, and physical technologies. Among these advancements, Artificial Intelligence (AI) has emerged as a transformative force reshaping industry, redefining job roles, and creating new pathways for innovation and entrepreneurship (Uctu et al., 2024; Chalmers et al., 2021). AI technologies such as machine learning, data analytics, and intelligent automation are increasingly influencing how businesses are conceived, developed, and sustained (Sipola et al., 2023). As a result, individuals are now required to possess not only technical expertise but also the capacity to apply intelligent technologies creatively in identifying opportunities and solving real-world problems.

Technical Vocational Education and Training (TVET) institutions play a critical role in preparing a skilled and adaptable workforce (Abdullah et al., 2020). TVET is designed to provide learners with practical, hands-on skills aligned with industry needs, making it a strategic platform for fostering entrepreneurship (Olomola & Shodiye, 2017). But, the traditional focus of TVET on manual and routine skills is gradually becoming insufficient in the face of technological disruptions brought about by AI (Mhlanga, 2024). There is a growing need for TVET systems to integrate AI competencies into their curricula and instructional practices in order to remain relevant and responsive to labour market demands (Okanya, 2023). Such integration is expected to enhance students' problem-solving abilities, creativity, and capacity to initiate innovative business ventures.

Entrepreneurial venture creation is the process of identifying a business opportunity, developing an innovative idea and establishing a new enterprise to exploit that opportunity for economic and social value creation. It involves individual's ability to identify certain economic problems, and deploying scarce resources to provide relief, services with the aim of making profit (Shodiye & Ohanu, 2020). Entrepreneurial venture creation has become increasingly important as economies seek to address unemployment and promote sustainable development (Ogamba, 2019). In Nigeria, youth unemployment remains a significant challenge, equipping TVET students with the skills to create and manage their own businesses is essential (Obi & Ojo, 2025). AI has the potential to support this objective by enabling students to analyze market trends, develop innovative solutions, and optimize business operations (Allil, 2024). AI-driven learning tools can also provide personalized learning experiences, simulate real-world business environments, and enhance students' entrepreneurial mindset (Kaswab et al., 2024). However, the extent to which these tools effectively translate into practical venture creation remains a subject of concern.

Furthermore, the successful integration of AI in TVET depends largely on institutional readiness, including the availability of digital infrastructure, access to AI tools, supportive policies, and the competence of instructors (Noor et al., 2025). Institutions that lack these enabling conditions may experience superficial or ineffective adoption, thereby limiting the capacity of students to acquire the competencies required for entrepreneurial venture creation. Therefore, AI competency integration, AI-driven learning tools, and institutional readiness constitute important dimensions through which TVET institutions can prepare students for entrepreneurial success in the fourth industrial revolution.

In Nigeria, the growing emphasis on digital transformation and entrepreneurship is reflected in the emergence of new innovation corridors and economic hubs in Lagos State.

Areas such as Epe have recently attracted significant attention due to ongoing investments in technology infrastructure, industrial development, and innovation-driven projects, including the establishment of Dangote refinery, the proposed Lekki International Airport, Lekki deep sea port, and the expansion of the Lekki Free Trade Zone. These developments signal Nigeria's increasing commitment to building a knowledge-based and technology-driven economy that requires a highly skilled and entrepreneurial workforce. Consequently, Technical Vocational Education and Training (TVET) institutions are expected to equip students with competencies in emerging technologies such as Artificial Intelligence (AI) to enable them to exploit new economic opportunities and contribute meaningfully to the country's evolving innovation ecosystem (Ahmad, 2020).

Despite the growing recognition of AI as a catalyst for educational transformation and entrepreneurship development, existing studies have predominantly focused on AI adoption, academic performance, digital competencies, and entrepreneurial intentions. Empirical evidence on how AI competency integration, AI-driven learning tools, and institutional readiness influence entrepreneurial venture creation among TVET students remains limited, particularly within the Nigerian context and in Epe, Lagos State. Furthermore, there is insufficient understanding of the extent to which AI integration in TVET translates into students' ability to create and sustain entrepreneurial ventures in emerging economic environments. This gap in knowledge necessitates an investigation into the influence of AI on entrepreneurial venture creation among TVET students in Epe, Lagos State.

Consequently, this study examines the influence of AI on entrepreneurial venture creation among TVET students in Epe, Lagos State, with a focus on AI competency integration, AI-driven learning tools, and institutional readiness. The findings of the study are expected to contribute to ongoing efforts to reposition TVET as a driver of innovation, entrepreneurship, employment generation, and sustainable economic development in the digital age.

Statement of the problem

The Fourth Industrial Revolution (4IR) has fundamentally transformed the nature of work, innovation, and entrepreneurship through the integration of advanced digital technologies such as Artificial Intelligence (AI), big data, automation, and intelligent systems. Consequently, Technical and Vocational Education and Training (TVET) institutions are expected to move beyond traditional skills training and equip learners with AI competencies that promote creativity, problem-solving, innovation, and entrepreneurial venture creation. In emerging innovation corridors TVET institutions are expected to produce graduates who can

leverage AI technologies to identify opportunities, develop innovative solutions, and establish sustainable ventures (Lakshmi et al., 2023).

However, evidence suggests that the integration of AI in TVET institutions remains inadequate and fragmented. AI competencies are not systematically embedded in curricula, instructional practices, and assessment processes (Zou et al., 2025), while access to AI-driven learning tools and digital infrastructure remains uneven across institutions (Assefa, 2025). Although some studies have shown that AI can enhance entrepreneurial knowledge, creativity, and opportunity recognition (Ge et al., 2022), there is limited evidence that these competencies are translating into actual entrepreneurial venture creation among TVET students. Similarly, institutional readiness in terms of infrastructure, policy support, instructor competence, and access to AI resources appears insufficient to support meaningful AI-driven entrepreneurship education, particularly in developing contexts such as Nigeria.

Despite the growing body of literature on AI in education and entrepreneurship, there is a paucity of empirical studies that examine how AI competency integration, AI-driven learning tools, and institutional readiness influence entrepreneurial venture creation among TVET students in emerging economic ecosystems in Epe, Lagos. Existing studies have largely focused on AI adoption, digital competencies, or entrepreneurial intentions, with little attention paid to the mechanisms through which AI integration in TVET contributes to venture creation in the Fourth Industrial Revolution. This knowledge gap necessitates the present study, which seeks to investigate the influence of AI and entrepreneurial venture creation in the fourth industrial revolution among TVET students in Epe, Lagos, with a view to providing evidence for strengthening TVET's contribution to innovation, employment generation, and sustainable economic development.

Literature Review

Conceptual framework

The conceptual framework of this study is based on the premise that the implementation of Artificial Intelligence (AI) in Technical and Vocational Education and Training (TVET) institutions influences entrepreneurial venture creation among students in the Fourth Industrial Revolution (4IR). The framework identifies three major dimensions of AI implementation in TVET institutions: AI competency integration, AI-driven learning tools, and institutional readiness. These dimensions are considered critical determinants of entrepreneurial venture creation among TVET students.

AI Competency Integration

AI competency integration refers to the deliberate and systematic incorporation of Artificial Intelligence (AI) knowledge, skills, tools, and applications into the curriculum, instructional practices, practical activities, and learning experiences of Technical and Vocational Education and Training (TVET) institutions. It involves exposing students to AI-related concepts such as machine learning, data analytics, intelligent automation, robotics, predictive technologies, and digital problem-solving while providing opportunities for hands-on engagement through projects, simulations, and industry-based tasks (Chee, et al., 2025). In the Fourth Industrial Revolution (4IR), AI competency integration is essential because it equips learners with the technological literacy and digital capabilities required to function effectively in increasingly technology-driven workplaces and entrepreneurial environments (Khoza, 2025). It also enables students to understand how intelligent technologies can be utilized to improve productivity, enhance decision-making, solve complex problems, and create value in diverse sectors of the economy (Chee et al., 2025; Khoza, 2025). Previous studies had investigated the integration of artificial intelligence in education and found that AI integration improves student performance and enhances learning process effectiveness (Zhou, 2023). In healthcare, AI significantly impact healthcare delivery in enhancing diagnostic precision, treatment personalization and facilitating predictive analytics (Olawade et al., 2024). Recent studies have also investigated AI in entrepreneurship and found that AI designed to automate are likely to result in higher level of necessity entrepreneurship while AI that transform jobs without needing to displace human worker increase the level of opportunity entrepreneurship (Fossen et al., 2024; Chen et al., 2024).

The framework assumes that greater integration of AI competencies into TVET programmes enhances students' entrepreneurial venture creation capabilities by developing their innovative thinking, opportunity recognition skills, creativity, and technological adaptability. As students acquire AI-related competencies, they become better equipped to identify emerging market needs, design technology-enabled solutions, and transform innovative ideas into viable business ventures (Mahmoud-Jouini et al., 2019). AI competency integration also strengthens students' ability to leverage data-driven insights, automate business processes, and develop competitive strategies that are critical for entrepreneurial success in the digital age (Mahmoud-Jouini et al., 2019). Therefore, the extent to which AI competencies are embedded in TVET curricula and instructional practices is expected to significantly influence students' capacity to initiate, manage, and sustain entrepreneurial ventures within the rapidly evolving 4IR ecosystem.

AI-Driven Learning Tools

AI-driven learning tools refer to intelligent, data-enabled technologies designed to enhance teaching and learning through automation, personalization, and real-time responsiveness. These tools include adaptive learning platforms that adjust content difficulty based on learner performance (Strielkowski et al., 2025), intelligent tutoring systems that simulate one-on-one human instruction, machine-learning algorithms that analyze learner behaviour (Ouyang & Zhang, 2024), virtual and augmented reality simulations for experiential practice, predictive analytics tools that identify learning gaps (Strielkowski et al., 2025), and automated assessment systems that provide instant, targeted feedback (Deepshikha, 2026). In addition, these tools often integrate learning management systems with AI-powered dashboards that support teacher in monitoring progress, improving instructional strategies, and tailoring interventions to individual or group needs (Cabral et al., 2025). Their design is grounded in learner-centered pedagogy, ensuring that students engage actively rather than passively receiving content (Meng et al., 2025). Previous studies investigated the implications of AI-driven learning tools on student's learning outcomes (Luo et al., 2025), promoting learners' engagement (Wang & Xue, 2024) and personalized instruction (Kawsan et al., 2024). Recent studies investigate its impact on opportunity recognition (Raimi et al., 2024) and innovativeness (Rajan, 2026).

AI-driven learning tools strengthen students' entrepreneurial competencies by providing immersive, practice-oriented experiences that mirror real-world business environments (Subrahmanyam, 2026). Through simulation-based learning, students can test business ideas, analyze market conditions, and make data-informed decisions without financial risk, while adaptive systems ensure continuous skill progression aligned with individual learning pace (Bautista, 2025). Furthermore, AI-enhanced feedback mechanisms foster critical thinking, creativity, and problem-solving by offering timely insights into performance and alternative strategies (Hajj et al., 2025). As a result, learners develop stronger digital literacy, opportunity recognition skills, and innovation capacity, enabling them to transform theoretical knowledge into actionable and sustainable business ventures in increasingly technology-driven economies.

Institutional readiness

Institutional readiness refers to the extent to which TVET institutions possess the structural, technological, human, and policy capacities required to effectively adopt and sustain AI-driven educational innovations (Anomah, 2025). It comprises the availability of robust

digital infrastructure such as reliable internet connectivity, smart classrooms, cloud-based learning systems, and access to AI-enabled software and tools (Assefa et al., 2021). It also includes institutional policies that support digital transformation, curriculum flexibility for emerging technologies, and governance frameworks that guide ethical and effective AI use in teaching and learning. Equally important are human resource factors, particularly the presence of adequately trained instructors, ICT-support personnel, and continuous professional development systems that equip staff with the competencies needed to integrate AI into pedagogy and assessment (Bahari & Liu, 2025). Financial sustainability and leadership commitment further determine the extent to which institutions can acquire, maintain, and scale AI resources over time. Previous studies have explored the relationship between institutional readiness and students learning outcome (Bubou & Job, 2022), employability skills (Herbert et al., 2020), and pedagogical innovations among teachers (Saboowala & Manghirmalani Mishra, 2021) but few studies had considered institutional readiness in relation to the adoption of emerging technologies.

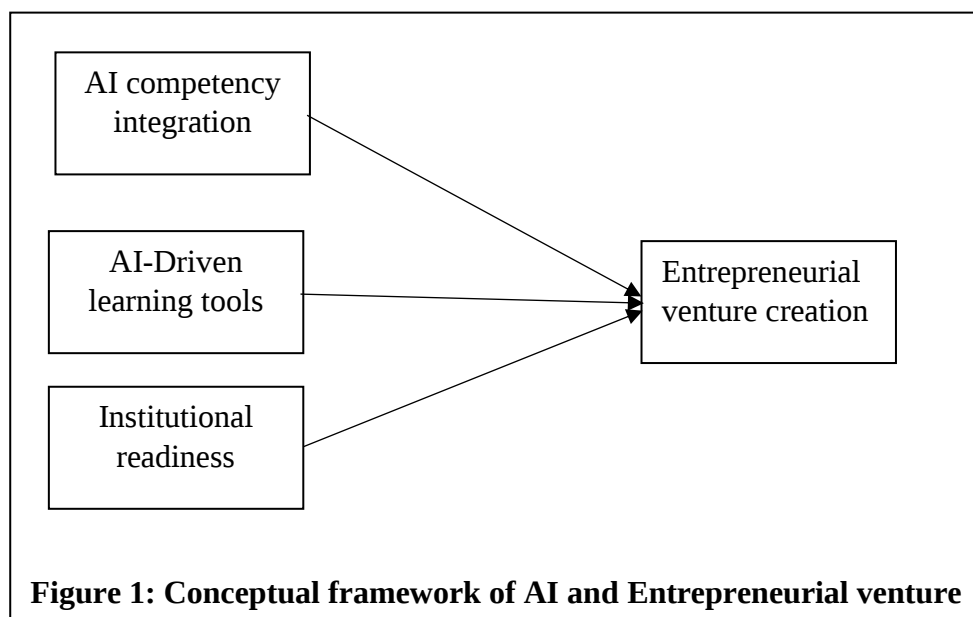
Institutional readiness plays a pivotal role in shaping the quality and effectiveness of AI integration for skills development. Institutions with high readiness levels create an enabling ecosystem where learners and teachers can actively engage with AI-driven tools to explore innovation, experiment with business ideas, and develop practical entrepreneurial competencies (Anomah, 2025). Such environments foster a culture of creativity, experimentation, and problem-solving by reducing barriers to technology access and encouraging interdisciplinary collaboration (Maria & Halim, 2026). In addition, strong institutional support systems enhance students' ability to translate theoretical knowledge into practical venture creation through guided practice, mentorship, and access to digital entrepreneurship platforms (Benhayoun et al., 2025). Ultimately, institutional readiness acts as a catalyst that determines how effectively AI technologies are leveraged to produce graduates who are not only digitally competent but also capable of generating and sustaining innovative business solutions in dynamic economic environments.

Entrepreneurial venture creation

Entrepreneurial venture creation is the comprehensive process through which students recognize viable business opportunities, generate innovative ideas, mobilize resources, and establish sustainable enterprises capable of operating in competitive and dynamic markets (Shodiye & Ohanu, 2020; Ohanu & Shodiye, 2021). It extends beyond mere business start-up to include opportunity evaluation, feasibility analysis, business model development, risk

assessment, market entry strategies, and long-term sustainability planning. In the Fourth Industrial Revolution, venture creation is increasingly shaped by digital transformation, where success depends on the ability to leverage emerging technologies such as artificial intelligence, big data analytics, automation, and digital platforms to design innovative products and services (Nambisan et al., 2019). These technologies not only enhance efficiency and scalability but also enable entrepreneurs to respond rapidly to changing consumer needs, global market trends, and disruptive economic shifts (Mishra & Sharma, 2025).

Entrepreneurial venture creation among TVET students is conceptualized as the outcome of a synergistic relationship between AI competency integration, AI-driven learning tools, and institutional readiness. AI competency integration equips learners with the cognitive and practical skills needed to apply AI concepts in solving real-world entrepreneurial problems (Tantrarungroj & Thangkabutra, 2025), while AI-driven learning tools provide experiential, personalized, and simulation-based environments that strengthen decision-making, creativity, and innovation capacity. Institutional readiness, on the other hand, ensures the availability of enabling infrastructure, skilled facilitators, supportive policies, and adequate resources that sustain effective AI adoption in teaching and learning.



Theoretical framework

Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM) (Davis, 1989) explains how individuals accept and use new technologies. The theory posits that two primary factors determine technology adoption: perceived usefulness and perceived ease of use. Perceived usefulness

refers to the degree to which an individual believes that using a technology will enhance performance (Chen & Aklikokou, 2020), perceived ease of use refers to the extent to which the technology is perceived as effortless to use (Chen & Aklikokou, 2020). TAM is quite relevant to this study. The theory explains students' acceptance and utilization of AI technologies in TVET institutions. AI-driven learning tools such as intelligent tutoring systems, predictive analytics platforms, virtual simulations, and automated feedback systems can only contribute to entrepreneurial venture creation when students perceive them as useful and easy to use (Schiavone et al., 2023; Chalmer et al., 2021). When learners recognize that AI tools enhance opportunity identification, business planning, market analysis, and innovation processes, they are more likely to adopt and utilize such technologies effectively. Consequently, increased utilization of AI technologies enhances entrepreneurial knowledge, creativity, problem-solving abilities, and venture creation competencies (Alvarez-Icaza et al., 2025). Furthermore, institutional readiness like infrastructure availability, providing technical support, and training opportunities, can improve students' perceptions of AI usefulness and ease of use, thereby promoting technology adoption and entrepreneurial outcomes (Raza et al., 2019).

Purpose of the Study

The general purpose of this study is to examine the influence of artificial intelligence (AI) on entrepreneurial venture creation in the fourth industrial revolution. Specifically, the study will find out:

1. The extent of integration of artificial intelligence competencies into curriculum and instructional practices of TVET institutions in Epe Lagos.
2. The extent to which AI-driven learning tools influence entrepreneurial knowledge and venture creation among TVET students.
3. The institutional readiness for AI adoption influences on entrepreneurial competencies among TVET students in Epe, Lagos.

Research Questions

1. What is the extent of integration of artificial intelligence (AI) competencies into the curriculum and instructional practices of TVET institutions in Epe, Lagos?
2. To what extent do AI-driven learning tools influence entrepreneurial knowledge and venture creation among TVET students?
3. How does institutional readiness for AI adoption influence entrepreneurial competencies among TVET learners in Epe, Lagos?

Hypotheses

1. There is no significant influence of AI competency integration in TVET curricula on entrepreneurial venture creation among students
2. There is no significant influence of AI-driven learning tools on entrepreneurial venture creation among students
3. There is no significant influence of institutional readiness on entrepreneurial venture creation among students

Methodology***Research Design***

The study adopted a descriptive research design. A survey is research which involves the assessment of several people's opinion using questionnaire and sampling method.

Area of the study

The study was conducted in Epe, Lagos State, because the area hosts several TVET institutions that emphasize skill acquisition and entrepreneurship development. The location was also selected due to the limited empirical evidence on the integration of artificial intelligence in TVET and its influence on entrepreneurial venture creation among students in the area, thereby providing an appropriate context for the study.

Sample and sampling techniques

The sample for the study comprised 204 respondents (190 TVET students and 14 lecturers) from tertiary TVET institutions in Epe, Lagos State. The area of study is selected because they offer specialized technical and vocational programmes because of their exposure to entrepreneurship education and emerging technologies. The student respondents were selected from the 100 to 400 levels to ensure adequate representation of students at different stages of their academic and entrepreneurial training. A multistage sampling technique was adopted for the study. In the first stage, the two universities in Epe, Lagos State, offering TVET programmes were purposively selected. In the second stage, all students enrolled in TVET programmes in the selected universities were grouped according to their levels of study. In the third stage, proportionate sampling was used to determine the number of respondents to be selected from each level based on the population of students in each stratum. Finally, simple random sampling was employed to select the required number of students from each level, while all the lecturers involved in teaching TVET courses in the selected institutions were included in the study.

Instrument for data collection

The instrument used for data collection was a researcher-developed questionnaire titled "Artificial Intelligence Integration and Entrepreneurial Venture Creation Questionnaire (AIEVCQ)." The questionnaire items were developed following an extensive review of relevant literature related to artificial intelligence integration and entrepreneurial venture creation in TVET. The instrument was measured on a five-point Likert scale. The instrument was subjected to content validity. The validation was done by three experts (a lecturer from computer and robotics education and two from Centre for Entrepreneurship Development) from Yaba College of Technology. Cronbach's alpha reliability coefficient was used to check the validity of the instrument after administering the instrument to 20 students from Tai-Solarin Federal University of Education, Ijebu Ode. The reliability of the instrument was 0.89.

Method of data collection

Data was collected from the sample through direct administration of the instrument with the assistance of two other research assistance.

Method of data analysis

The data collected was analyzed using descriptive statistics for the research questions while regression analysis was used to analyze the hypotheses. A mean response of 1.00 – 1.80 – very low extent, 1.81 – 2.60 – low extent, 2.61 – 3.40 – moderate extent, 3.41 – 4.20 – high extent, 4.21 – 5.00 very high extent. Also, the mean response below 3.0 was disagree while a mean 3.0 and above is agree. The hypothesis below 0.05 below implies that the null hypotheses was rejected, accepting the alternate hypotheses.

Results

Research Question 1: What is the extent of integration of artificial intelligence (AI) competencies into the curriculum and instructional practices of TVET institutions in Epe, Lagos?

The findings in Table 1 revealed that Items 2, and 4 with mean score of 3.51 and 3.48 were rated at high extent. Items 1, 3, 5 and 6, with mean scores of 2.68, 3.28, 3.28, and 2.74 respectively, were all rated at a moderate extent. The results indicate that instructors actively incorporate AI applications in teaching and learning and that teaching methods increasingly reflect the use of AI for instructional delivery. These relatively high mean values, coupled with low standard deviations, indicate a fairly consistent perception among respondents that AI is gaining traction in classroom practices, particularly through instructors' efforts. However, other critical areas reflect only a moderate extent of integration. The exposure of students to

practical AI applications and opportunities for hands-on engagement with AI technologies, the embedding of AI tools across curriculum content and the integration of AI into assessment and feedback processes recorded were rated at a moderate extent. This suggests that AI adoption is still limited at the structural and systemic levels, especially in curriculum design and evaluation mechanisms.

Table 1: Integration of artificial intelligence (AI) competencies into the curriculum and instructional practices of TVET institutions

S/N	Integration of artificial intelligence (AI) competencies into the curriculum and instructional practices of TVET institutions	Mean	Std. Dev	Decision
1	Artificial intelligence tools are systematically embedded in the curriculum content across different courses in this institution.	2.68	.95	Moderate Extent
2	Instructors in this institution actively incorporate artificial intelligence applications to support teaching and learning activities.	3.51	.57	High Extent
3	The curriculum is structured to expose students to practical use of artificial intelligence relevant to their technical or vocational field.	3.28	.58	Moderate Extent
4	Teaching methods in this institution increasingly reflect the use of artificial intelligence for enhancing instructional delivery.	3.48	.68	High Extent
5	Students are provided with opportunities to engage with artificial intelligence technologies during classroom and workshop activities.	3.28	.63	Moderate Extent
6	The institution integrates artificial intelligence into assessment and feedback processes to improve students' learning outcomes.	2.74	.79	Moderate Extent

Research Question 2: To what extent do AI-driven learning tools influence entrepreneurial knowledge and venture creation among TVET students?

Table 2: AI-driven learning tools influence entrepreneurial knowledge and venture creation among TVET students

S/N	AI driven learning tools influence entrepreneurial knowledge and venture creation intentions among TVET students	Mean	Std. Dev	Decision
1	The use of AI-driven learning tools has significantly improved my understanding of entrepreneurial concepts and business development.	3.64	.59	High Extent
2	AI-based learning platforms have enhanced my ability to identify viable business opportunities in my field of study.	3.22	.76	Moderate Extent

3	Interaction with AI-driven instructional tools has strengthened my confidence to start and manage a business venture.	3.59	.55	High Extent
4	AI-supported learning experiences have influenced my intention to establish a business after completing my training.	2.74	.90	Moderate Extent
5	The integration of AI tools in my learning has equipped me with practical knowledge required for venture creation.	3.30	.52	Moderate Extent

The findings in Table 2 indicated that Items 1, 3, and 5, with mean scores of 3.64, 3.59, and 3.30 respectively, were rated at a high extent. This suggests that AI-driven learning tools are effective in enhancing students' understanding of entrepreneurial concepts, building confidence to start and manage a business, and providing practical knowledge for venture creation. These findings imply that AI tools contribute meaningfully to entrepreneurial knowledge acquisition and self-efficacy, which are essential foundations for entrepreneurship. However, Items 2 and 4, with mean scores of 3.22 and 2.74 respectively, were rated at a moderate extent, indicating important limitations. Specifically, AI tools appear to have good impact on students' ability to identify viable business opportunities and a strong influence on their intention to establish a business after training. This suggests that although students acquire entrepreneurial knowledge and confidence through AI-driven learning tools, these gains do not consistently translate into a strong entrepreneurial intention or actual venture creation. Therefore, additional support mechanisms may be necessary to convert entrepreneurial knowledge into entrepreneurial action. Also, the standard deviation ranges from 0.52 to 0.90 which indicate that the respondents are close in their response on the influence of AI-driven learning tools on entrepreneurial knowledge and venture creation intentions among TVET students

Research Question 3: How does institutional readiness for AI adoption influence entrepreneurial competencies among TVET learners in Epe, Lagos?

The findings in Table 3 indicated that items 1, 2, 3, 5, and 6, with mean scores ranging from 3.10 to 3.48, indicate that respondents agree that institutional readiness for AI adoption enhances their entrepreneurial competencies. Specifically, the availability of AI infrastructure, institutional support, and readiness to integrate AI into learning are perceived to improve entrepreneurial skills, foster innovative thinking, and strengthen problem-solving abilities required for venture creation. Additionally, institutional policies and training related to AI are seen to enhance creativity and build competence in developing viable business ventures.

However, Item 4, with a mean score of 2.42, was in disagreement, indicating that respondents do not perceive adequate access to AI tools and resources as contributing significantly to their ability to create and manage business opportunities. This suggests a gap between institutional readiness in principle (policies, support, training) and actual access to AI resources, which may hinder the practical application of entrepreneurial skills. Also, the standard deviation, most values range from 0.57 to 0.89, indicating that respondents' opinions are closely clustered around the mean, reflecting a high level of agreement and consistency in their responses. This implies that the majority share similar views regarding the positive influence of institutional readiness on entrepreneurial competencies.

Table 3: Institutional readiness for AI adoption on entrepreneurial competencies among TVET learners.

S/N	Institutional readiness for AI adoption influence entrepreneurial competencies among TVET learners in Epe, Lagos	Mean	Std. Dev	Decision
1	The availability of AI-related infrastructure in my institution enhances my ability to develop entrepreneurial skills.	3.37	.59	Agree
2	Institutional support for AI adoption improves my capacity to apply innovative ideas in business-related activities.	3.26	.71	Agree
3	The readiness of my institution to integrate AI into learning strengthens my problem-solving skills for entrepreneurial ventures.	3.34	.57	Agree
4	Access to AI tools and resources in my institution promotes my ability to create and manage business opportunities.	2.42	1.03	Disagree
5	Institutional policies and initiatives supporting AI adoption enhance my creativity and innovation in entrepreneurship.	3.48	.70	Agree
6	Training and guidance provided by my institution on AI usage improve my competence in developing viable business ventures.	3.10	.89	Agree

Hypothesis 1: There is no significant influence of AI competency integration in TVET curricula on entrepreneurial venture creation among students

Table 4: AI competency integration in TVET curricula on entrepreneurial venture creation among students

Model	R	R Square	Adjusted R Square	Std. Error	β	p-value
1	0.249 ^a	0.062	0.058	.513	.249	0.000

a. Dependent variable: Entrepreneurial Venture Creation

b. Predictor: (Constant), AI competency Integration

The findings in Table 4 indicate that AI competency integration in TVET curricula has a significant influence on entrepreneurial venture creation among students ($F(1, 202) = 32.418$, $p < 0.05$). The regression model explains a proportion of the variance in entrepreneurial venture creation, with an R^2 value of 0.062, suggesting that AI competency integration accounts for 6.2% of the observed variability in the entrepreneurial venture creation. Although the explanatory power of the model is modest, the significant F-statistic implies that the predictor meaningfully contributes to changes in entrepreneurial venture creation outcomes. Consequently, the null hypothesis of no significant influence is rejected, indicating that the integration of AI competencies within TVET curricula plays a critical, albeit limited, role in enhancing students' entrepreneurial venture creation capabilities.

Hypothesis 2: There is no significant influence of AI driven learning tools on entrepreneurial venture creature among TVET students

Table 5: AI driven learning tools on entrepreneurial venture creature among TVET students

Model	R	R Square	Adjusted R Square	Std. Error	β	p-value
1	0.498 ^a	0.248	0.244	.504	0.498	.000

a. Dependent variable: Entrepreneurial Venture Creation

b. Predictor: (Constant), AI-Driven Learning Tools

The findings in Table 5 reveal that AI-driven learning tools have a significant influence on entrepreneurial venture creation among TVET students ($F(1, 202) = 33.421$, $p < 0.05$). The significance value of 0.000 indicates that the model is robust and that the predictor meaningfully contributes to explaining variations in the dependent variable. Furthermore, the R^2 value of 0.248 suggests that AI-driven learning tools account for 24.8% of the variance in entrepreneurial venture creation, indicating a moderate predictive power. This implies that the use of AI-driven learning tools substantially enhances students' capacity for entrepreneurial venture creation. Consequently, the null hypothesis of no significant influence is rejected, affirming that AI-driven learning tools play a critical and practically meaningful role in fostering entrepreneurial venture creation among TVET students, although additional factors may still contribute to the unexplained variance.

Hypothesis 3: There is no significant influence of institutional readiness on entrepreneurial venture creature among TVET students

Table 6: Institutional readiness on entrepreneurial venture creature among TVET students

Model	R	R Square	Adjusted R Square	Std. Error	β	p-value
1	0.412 ^a	0.170	0.166	.427	.412	.000

a. Dependent variable: Entrepreneurial Venture Creation

b. Predictor: (Constant), Institutional Readiness

The findings indicate that institutional readiness has a significant influence on entrepreneurial venture creation among TVET students ($F(1, 202) = 41.286, p < 0.05$). The significance value of 0.000 confirms that the regression model is robust and that institutional readiness is a meaningful predictor of the entrepreneurial venture creation among TVET students. The R^2 value of 0.170 shows that institutional readiness explains 17.0% of the variance in entrepreneurial venture creation. This suggests that institutions that are better prepared in terms of infrastructure, policy support, and resource availability are more likely to enhance students' entrepreneurial venture creation capabilities. Consequently, the null hypothesis of no significant influence is rejected, highlighting the important role of institutional readiness in fostering entrepreneurial outcomes among TVET students.

Discussion of the Findings

The findings reveal that AI competency integration in TVET curricula significantly influences entrepreneurial venture creation among students. Therefore, hypothesis 1 is rejected. This result aligns with previous studies, in which digital and AI competencies were found to foster innovation, problem-solving, and opportunity recognition that are core elements of entrepreneurship (Alvarez-Icaza et al., 2025; Yordudom et al., 2026). This is also supported by studies such as Prokopenko et al. (2020) and Verma et al. (2025), who argue that embedding AI competencies in educational curricula enhances learners' capacity to engage with emerging technologies in productive and entrepreneurial ways. The result implies that AI competency integration, although important, remains at a developmental stage within TVET systems and requires deeper pedagogical integration, hands-on learning opportunities, and alignment with industry practices to yield stronger entrepreneurial impacts.

The findings demonstrate that AI-driven learning tools have a significant and meaningful influence on entrepreneurial venture creation among TVET students. So,

hypothesis 2 is rejected. This finding aligns with studies emphasizing that AI-driven learning environments enhance experiential learning, creativity, and problem-solving skills critical to entrepreneurship (Nweke et al., 2025; Napier & Wada, 2024). Also, studies by Csaszar et al. (2025) and Esmaeilzadeh and Maddah (2026) highlight that AI-enabled tools support personalized and practice-oriented learning, thereby improving learners' ability to translate knowledge into innovative business ideas and ventures. The study suggests that AI-driven tools are more directly linked to practical skill acquisition and application than mere curriculum integration, as they provide hands-on, interactive, and real-time feedback experiences.

The findings indicate that institutional readiness significantly influences entrepreneurial venture creation among TVET students, leading to the rejection of the null hypothesis. The result is consistent with prior studies emphasizing that a supportive institutional environment plays a critical role in shaping entrepreneurial intentions and venture creation (Bui et al., 2023; Tetteh et al., 2024). Similarly, Bläse et al. (2025) highlight that enabling ecosystem, including institutional support structures, are essential for nurturing entrepreneurship. This suggests that institutions that are well-prepared in terms of infrastructure, policy frameworks, and resource availability are better positioned to support the development of students' entrepreneurial competencies.

Conclusion

The study concludes that the effective integration of artificial intelligence (AI) in Technical and Vocational Education and Training (TVET) is essential for fostering entrepreneurial capacity in the Fourth Industrial Revolution (4IR) era. Empirical evidence demonstrates that AI competency integration, AI-driven learning tools, and institutional readiness each exert a positive and significant influence on entrepreneurial venture creation among TVET students, leading to the rejection of all null hypotheses. Notably, AI-driven learning tools emerged as the strongest predictor, highlighting their critical role in translating learning experiences into practical entrepreneurial competencies. Although AI competency integration within curricula was found to be significant, its relatively low predictive power suggests that it remains at a developmental stage and requires deeper and more systematic embedding into instructional and assessment practices. Furthermore, institutional readiness significantly supports entrepreneurial development through the provision of infrastructure, policy frameworks, and capacity-building initiatives, although disparities in access to AI resources persist.

Recommendations

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

1. TVET students should actively engage with AI-driven learning tools to build practical entrepreneurial competencies, particularly in opportunity identification and venture initiation, where the results showed relatively weaker outcomes. They should also pursue self-directed learning to complement institutional provisions and translate AI exposure into actionable business ideas.
2. Educators should deepen the pedagogical integration of AI by embedding it into instructional delivery, assessment, and project-based learning activities, ensuring that AI usage goes beyond basic exposure to fostering innovation, critical thinking, and venture creation skills.
3. TVET institutions prioritize AI-focused curriculum development, invest in digital infrastructure, and strengthen industry collaborations to equip students with relevant competencies for sustainable venture creation.
4. Government agencies should provide targeted funding and infrastructural support for AI adoption in TVET, particularly to address gaps in access to AI tools and resources identified in the findings.
5. Education policymakers should develop and implement clear national frameworks for AI integration in TVET, ensuring standardization, quality assurance, and alignment with 4IR workforce and entrepreneurship demands.
6. Industry stakeholders should collaborate with TVET institutions to provide AI-enabled platforms, mentorship, and real-world entrepreneurial ecosystems that enhance students' ability to translate learning into viable ventures.

References

- Abdullah, N. S., Sumarwati, S., & Abd Aziz, M. I. (2020). Life and career skills among technical and vocational education and training (TVET) students in vocational colleges. *Online Journal for TVET Practitioners*, 5(2), 20-26.
- Ahmad, T. (2020). Scenario based approach to re-imagining future of higher education which prepares students for the future of work. *Higher Education, Skills and Work-Based Learning*, 10(1), 217-238.
- Allil, K. (2024). Integrating AI-driven marketing analytics techniques into the classroom: pedagogical strategies for enhancing student engagement and future business success. *Journal of Marketing Analytics*, 12(2), 142-168.
- Alvarez-Icaza, I., Miranda, J., Martínez-Arboleda, A., Suárez-Brito, P., & Ramírez-Montoya, M. S. (2025). Driving complex thinking and technological entrepreneurship with artificial intelligence: a mixed methods study. *Sustainable Futures*, 10, 101312.
-

- Alvarez-Icaza, I., Miranda, J., Martínez-Arboleda, A., Suárez-Brito, P., & Ramírez-Montoya, M. S. (2025). Driving complex thinking and technological entrepreneurship with artificial intelligence: a mixed methods study. *Sustainable Futures*, 10, 101312.
- Anomah, S. (2025). Assessing the institutional readiness and capacity for AI adoption in public audit institutions in developing countries: Evidence from Ghana. *Telematics and Informatics Reports*, 20, 100260.
- Assefa, E. A. (2025). AI and the digital divide in ensuring educational access and multicultural inclusivity. *Journal of Information, Communication and Ethics in Society*.
- Assefa, S., Rorissa, A., & Alemneh, D. (2021). Digital readiness assessment of countries in Africa: a case study research. *Proceedings of the Association for Information Science and Technology*, 58(1), 400-404.
- Bahari, A., & Liu, Y. (2025). AI integration in EFL teacher development: a mixed-methods evaluation of digital competency, professional trajectories, and pedagogical innovation within adaptive learning ecosystems. *Interactive Learning Environments*, 1-17.
- Bautista, Y. J. P. (2026). Bridging Education and Entrepreneurial Digital Transformation: Cultivating Digital Literacy and Innovation. *Transformative Cloud Computing, IoT and Extended Reality: Applications for Smart Cities, Education, Healthcare, Industry and Business*, 183-198.
- Bläse, R., Filser, M., Weise, J., Björck, A., & Puumalainen, K. (2025). Identifying institutional gaps: Implications for an early-stage support framework for impact entrepreneurs. *Corporate social responsibility and environmental management*, 32(1), 679-697.
- Bubou, G. M., & Job, G. C. (2022). Individual innovativeness, self-efficacy and e-learning readiness of students of Yenagoa study centre, National Open University of Nigeria. *Journal of Research in Innovative Teaching & Learning*, 15(1), 2-22.
- Bui, D. T., Vu, T. N., Tran, T. V. H., Duong, C. D., & Le, T. L. (2023). Impact of institutional environment on social entrepreneurial intentions. *Journal of Open Innovation: Technology, Market, and Complexity*, 9(3), 100120..
- Bui, D. T., Vu, T. N., Tran, T. V. H., Duong, C. D., & Le, T. L. (2023). Impact of institutional environment on social entrepreneurial intentions. *Journal of Open Innovation: Technology, Market, and Complexity*, 9(3), 100120..
- Cabral, L., Pinto, R., & Gonçalves, G. (2025). AI-powered learning analytics dashboards: a systematic review of applications, techniques, and research gaps. *Discover Education*, 4(1), 525.
- Chalmers, D., MacKenzie, N. G., & Carter, S. (2021). Artificial intelligence and entrepreneurship: Implications for venture creation in the fourth industrial revolution. *Entrepreneurship Theory and Practice*, 45(5), 1028-1053.
- Chalmers, D., MacKenzie, N. G., & Carter, S. (2021). Artificial intelligence and entrepreneurship: Implications for venture creation in the fourth industrial revolution. *Entrepreneurship Theory and Practice*, 45(5), 1028-1053.
- Chee, H., Ahn, S., & Lee, J. (2025). A competency framework for AI literacy: Variations by different learner groups and an implied learning pathway. *British Journal of Educational Technology*, 56(5), 2146-2182.
- Chen, L., & Aklikokou, A. K. (2020). Determinants of E-government adoption: testing the mediating effects of perceived usefulness and perceived ease of use. *International Journal of Public Administration*, 43(10), 850-865.

- Chen, L., Ifenthaler, D., Yau, J. Y. K., & Sun, W. (2024). Artificial intelligence in entrepreneurship education: a scoping review. *Education+ Training*, 66(6), 589-608.
- Csaszar, F. A., Jacobides, M. G., & Zemsky, P. (2025). The effects of artificial intelligence on management education. *Strategic Organization*, 14761270251385484.
- Csaszar, F. A., Jacobides, M. G., & Zemsky, P. (2025). The effects of artificial intelligence on management education. *Strategic Organization*, 14761270251385484.
- Csaszar, F. A., Jacobides, M. G., & Zemsky, P. (2025). The effects of artificial intelligence on management education. *Strategic Organization*, 14761270251385484.
- Davis, F. D. (1989). Technology acceptance model: TAM. *AI-Suqri, MN, Al-Aufi, AS: Information seeking behavior and technology adoption*, 205(219), 5.
- Deepshikha, D. (2026). A systematic review on the future of educational assessment: AI-driven grading and personalised feedback in higher education. In *Artificial Intelligence in Education* (Vol. 2, No. 2, pp. 75-115). Emerald Publishing Limited.
- Esmailzadeh, P., & Maddah, M. (2026). AI-enhanced health information exchange systems: a systematic review of implementation challenges and opportunities. *Health Systems*, 1-33.
- Fossen, F. M., McLemore, T., & Sorgner, A. (2024). Artificial intelligence and entrepreneurship. *Foundations and Trends in Entrepreneurship*, 20(8), 781-904.
- Ge, B., Wang, Q., & Yao, M. (2022). From ideas to entrepreneurial opportunity: A study on AI. *Systems Research and Behavioral Science*, 39(3), 618-632.
- Hajj, C., Schmitt, C., & Azoury, N. (2025). Enhancing Problem-Solving Skills with AI: A Case Study on Innovation and Creativity in a Business Setting. *Administrative Sciences*, 15(10), 388.
- Kaswan, K. S., Dhatwal, J. S., & Ojha, R. P. (2024). AI in personalized learning. In *Advances in technological innovations in higher education* (pp. 103-117). CRC Press.
- Khoza, S. B. (2025). Justice in Curriculum: Coming Closer to Educating the Natural Reality of the Fourth or Fifth Industrial Revolution (4IR/5IR). *Africa Education Review*, 21(3), 1-11.
- Lakshmi, A. J., Kumar, A., Kumar, M. S., Patel, S. I., Naik, S. L., & Ramesh, J. V. N. (2023). Artificial intelligence in steering the digital transformation of collaborative technical education. *The Journal of High Technology Management Research*, 34(2), 100467.
- Luo, J., Zheng, C., Yin, J., & Teo, H. H. (2025). Design and assessment of AI-based learning tools in higher education: A systematic review. *International Journal of Educational Technology in Higher Education*, 22(1), 42.
- Meng, X., Yang, B., Yang, L., Zhang, J., & Liu, Y. (2025). A Novel AI-Empowered, Student-Centered Teaching Strategy for Large Classes in Higher Education: X. Meng et al. *International Journal of Science and Mathematics Education*, 23(7), 3093-3121.
- Mhlana, D. (2024). Digital transformation of education, the limitations and prospects of introducing the fourth industrial revolution asynchronous online learning in emerging markets. *Discover education*, 3(1), 32.
- Mishra, N., & Sharma, V. (2025). Emerging and disruptive technologies in entrepreneurship for global societies. In *Emerging Disruptive Technologies for Society 5.0 in Developing Countries: Challenges and Applications* (pp. 49-59). Cham: Springer Nature Switzerland.
- Nambisan, S., Wright, M., & Feldman, M. (2019). The digital transformation of innovation and entrepreneurship: Progress, challenges and key themes. *Research policy*, 48(8), 103773.

- Napier, P., & Wada, T. (2024). Bridging the skills gap: The design education landscape with AI and experiential learning. *Design Management Journal*, 19(1), 19-30.
- Noor, A. A. M., Hussein, S. S., Mustaffa, M., Lokman, A. M., & Alfiansyah, M. W. (2025). Developing Understanding of AI-Powered Personalized Learning Concept in TVET Institutions. *Journal of Technical Education and Training*, 17(3), 150-166.
- Nweke, L. O., Okebanama, U. F., & Mba, G. U. (2025). Enhancing entrepreneurial skills through experiential learning in IoT, AI, and cybersecurity. *Discover Education*, 4(1), 149.
- Obi, J. N., & Ojo, E. (2025). Enhancing employability through vocational and technical skill development among youths and adults in Nigeria. *African Journal of Applied Research*, 11(2), 478-495.
- Ogamba, I. K. (2019). Millennials empowerment: youth entrepreneurship for sustainable development. *World Journal of Entrepreneurship, Management and Sustainable Development*, 15(3), 267-278.
- Ohanu, I. B., & Shodipe, T. O. (2021). Influence of the link between resources and behavioural factors on the entrepreneurial intentions of electrical installation and maintenance work students. *Journal of Innovation and Entrepreneurship*, 10(1), 13.
- Okanya, V. (2023). Enhancing integration of emerging technologies in technical vocational education and training (TVET) programmes for sustainable development. *Industrial Technology Education Research Journal*, 6(1), 73-85.
- Olawade, D. B., David-Olawade, A. C., Wada, O. Z., Asaolu, A. J., Adereni, T., & Ling, J. (2024). Artificial intelligence in healthcare delivery: Prospects and pitfalls. *Journal of Medicine, Surgery, and Public Health*, 3, 100108.
- Olomola, B.T. & Shodipe, O.T (2017). [Nigeria beyond job scarcity: the role of technical and vocational education and training \(TVET\)](#). *Journal of Economic Development Research and Investment*. 8(1),
- Ouyang, F., & Zhang, L. (2024). AI-driven learning analytics applications and tools in computer-supported collaborative learning: A systematic review. *Educational Research Review*, 44, 100616.
- Prokopenko, O., Jarvis, M., Bielialov, T., Omelyanenko, V., & Malheiro, T. (2024, June). The future of entrepreneurship: Bridging the innovation skills gap through digital learning. In *International Conference Innovation in Engineering* (pp. 206-230). Cham: Springer Nature Switzerland.
- Raimi, L., Bamiro, N. B., & Lim, S. A. (2024). Two facets of AI-driven applications for sustainable learning and development: a systematic review of tech-entrepreneurial benefits and threats to creative learning. *Social Responsibility, Technology and AI*, 223-248.
- Rajan, P. R. (2026). Empowering learning: How AI drives innovation, enhances deep learning, and elevates student well-being. In *Intelligent Systems for Neurocognition and Human-Robot-Computer Interaction* (pp. 155-182). Academic Press.
- Raza, A., Muffatto, M., & Saeed, S. (2019). The influence of formal institutions on the relationship between entrepreneurial readiness and entrepreneurial behaviour: a cross-country analysis. *Journal of small business and enterprise development*, 26(1), 133-157.
- Saboowala, R., & Manghirmalani Mishra, P. (2021). Readiness of in-service teachers toward a blended learning approach as a learning pedagogy in the post-COVID-19 Era. *Journal of Educational Technology Systems*, 50(1), 9-23.

- Schiavone, F., Pietronudo, M. C., Sabetta, A., & Bernhard, F. (2023). Designing AI implications in the venture creation process. *International Journal of Entrepreneurial Behavior & Research*, 29(4), 838-859.
- Shodipe, T. O., & Ohanu, I. B. (2020). Antecedents of entrepreneurial intentions of electrical installation and maintenance work students' in technical colleges. *Asia Pacific Journal of Innovation and Entrepreneurship*, 14(2), 127-137.
- Sipola, J., Saunila, M., & Ukko, J. (2023). Adopting artificial intelligence in sustainable business. *Journal of Cleaner Production*, 426, 139197.
- Strielkowski, W., Grebennikova, V., Lisovskiy, A., Rakhimova, G., & Vasileva, T. (2025). AI-driven adaptive learning for sustainable educational transformation. *Sustainable development*, 33(2), 1921-1947.
- Subrahmanyam, S. (2026). Empowering Business Through Contemporary Technology Instruction: Global Perspectives, Practices, and Societal Impact. In *Global Perspectives on Social Empowerment Using Current Technology* (pp. 85-118). IGI Global Scientific Publishing.
- Tantrarungroj, P., & Thangkabut, T. (2025). A responsive and agentic artificial intelligence-driven online learning framework for personalized digital competency development among digital industry entrepreneurs. *Journal of Research in Innovative Teaching & Learning*, 1-16.
- Tetteh, C., Tasavori, M., Bhattarai, C. R., Zaefarian, R., & Rajwani, T. (2024). How do environmental factors shape entrepreneurial intention? A review and future research. *International Entrepreneurship and Management Journal*, 20(4), 2955-2977.
- Uctu, R., Tulu, N. S. H., & Aykac, M. (2024). Creative destruction and artificial intelligence: The transformation of industries during the sixth wave. *Journal of Economy and Technology*, 2, 296-309.
- Verma, R., Verma, S. K., Srivastava, R., Verma, S. B., & Singh, B. K. (2025). Utilizing AI and Digital Twin Technology to Cultivate Entrepreneurial Mindsets and Foster Creativity in Management Education: A Cornerstone for Corporate Readiness 5.0. In *Digital Twins for Smart Cities and Urban Planning* (pp. 194-209). CRC Press.
- Wang, Y., & Xue, L. (2024). Using AI-driven chatbots to foster Chinese EFL students' academic engagement: An intervention study. *Computers in Human Behavior*, 159, 108353.
- Yordudom, T., Nui-Suk, C., Imjai, N., Sumiati, S., & Aujirapongpan, S. (2026). Developing open innovation competency in Gen Z entrepreneurship students: Roles of absorptive capacity, AI literacy and algorithmic thinking skills. *The International Journal of Management Education*, 24(1), 101326.
- Zhou, C. (2023). Integration of modern technologies in higher education on the example of artificial intelligence use. *Education and Information Technologies*, 28(4), 3893-3910.
- Zou, D., Xie, H., & Kohnke, L. (2025). Navigating the future: establishing a framework for educators' pedagogic artificial intelligence competence. *European Journal of Education*, 60(2), e70117.