IJCER

International Journal of Contemporary Educational Research

IJCER

About the Journal

Journal Name	International Journal of Contemporary Educational Research
Abbreviation Name of the Journal	IJCER
e-ISSN	2148-3868
Publication Frequency	Four issues in year (March, June, September & December)
Journal Website	www.ijcer.net
Start Publishing	31.01.2014
Chief Editor	Prof. Dr. Mehmet Nuri Gömleksiz
Publisher	Asya Publishing&Consultancy
Country of Publication	Türkiye
Publication Type	Open access
Publication Content	International Journal of Contemporary Educational Research contains original scientific publications. All published papers, except editorial manuscripts, are subject to a double blind peer review process.
Audience	The target audience is members of the profession, teachers, school administrators, experts, researchers, master's and doctoral students as well as students related to this field with all fields of educational sciences. It aims to contribute to the spread of continuous professional development and research culture.
Publication Language	English

About

The aim of the journal is to contribute to science by publishing high quality publications of scientific importance. For this purpose, research articles, reviews, case reports and letters to the editor are published. The International Journal of Contemporary Educational Research (IJCER) focuses on publishing high-quality scholarly research that addresses key issues in educational sciences and aligns with the journal's defined aims and scope. In particularly, papers on teaching and teacher education, educational administration, counselling and student services, rural education and small schools, elementary and early childhood education, higher education, adult-career and vocational education, assessment and evaluation are welcome. Papers on science, reading, English and communication education, disabilities and gifted education, mathematics and environmental education, social studies and social science education, and urban education are also considered for publication. International Journal of Contemporary Educational Research is an independent, double-blind peer-reviewed, open access and online journal that aims to publish papers in all fields related to educational sciences. Papers should describe original data that have not been previously published or submitted for publication elsewhere. Manuscripts that are deemed suitable for the International Journal of Contemporary Educational Research submission rules and the scope of the journal are sent to at least two reviewer who are experts in their fields for scientific evaluation. The members of the Editorial Board of the International Journal of Contemporary Educational Research discuss the suitability of the manuscript and then take into account the reviewers comments on each submission. The final decision for all submitted manuscripts rests with the Editor-in-Chief. The Editorial Board of the International Journal of Contemporary Educational Research is committed to complying with the criteria of the International Council of Medical Journal Editors (ICMJE), World Association of Medical Editors (WAME) and Committee on Publication Ethics (COPE).

Peer-Review   Double anonymized - Double Blind

Plagiarism Checks   iThenticate & Turnitin

Scope: Guidance and Psychological Counseling
Dr. Kuan-Ming Chen | ID | ⌗ | ♦ | ◖ | SC
National Academy For Educational Research, Taiwan

Scope: Guidance and Psychological Counseling
Assoc. Prof. Erol Uğur | ID | ⌗ | ♦ | ◖ | SC
Düzce University, Türkiye

Scope: Computer and Instructional Technologies
Assist. Prof. Ahmet Uyar | ID | ⌗ | ♦ | ◖ |
Hatay Mustafa Kemal University, Türkiye

Scope: Pre-School Teacher Education
Assist. Prof. Buket Şen | ID | ⌗ | ♦ |
Munzur University, Türkiye

Scope: Turkish Education & Social Studies Teacher Education
Assist. Prof. Tuğrul Gökmen Şahin | ID | ⌗ | ♦ | ◖
İnönü University, Türkiye

Scope: Elementary School Teacher Education & Special Education Teaching
Assist. Prof. Erdal Zengin | ID | ⌗ | ◖ | SC
Fırat University, Türkiye

Scope: Foreign Languages Education & English Language Teaching
Assist. Prof. Ayşe Merzifonluoğlu | ID | ⌗ | ♦ | ◖ | SC
Erzincan Binali Yıldırım University, Türkiye

Scope: Department of Mathematıcs and Science Teaching-
Assist. Prof. Yasemin Abalı Öztürk | ID | ⌗ | ♦ | ◖ | SC
Çanakkale Onsekiz Mart University, Türkiye

Scope: Department of Mathematıcs and Science Teaching-
Assoc. Prof. Ayten Arslan | ID | ⌗ | ♦ | ◖ | SC
Muş Alparslan University, Türkiye

Indexing

International Journal of Contemporary Educational Research is indexed by the following indices:

Education Resources Information Center (ERIC)
Education Full Text (H. W. Wilson) Database Covarage List
Directory of Open Access Journals (DOAJ)
European Reference Index for the Humanities and Social Sciences (ERIH PLUS)

International Journal of Contemporary Education Research is indexed on the following digital platforms:

Index Copernicus (ICI)
Sosyal Bilimler Atıf Dizini (SOBİAD)
Scientific Indexing Services (SIS)
Türk Eğitim İndeksi (TEİ)
Open Academic Journals Index (OAJI)
Directory of Research Journals Indexing (DRJI)
Scientific Indexing Services (SIS)

Table of Contents

Empowering University Curriculum System Development with China's New Quality Productive Forces: A Case Study of Power Electronics Technology Course

Yingchun Xiao[1] | (iD) | xiaoyclzcu@163.com
Lan Zhou City University, Bailie School of Petroleum Engineering, Lanzhou, China
Xianyu Liu | (iD) | 2678188532@qq.com
Lan Zhou City University, Bailie School of Petroleum Engineering, Lanzhou, China
Zhonge Su | (iD) | 46263979@qq.com
Lan Zhou City University, Bailie School of Petroleum Engineering, Lanzhou, China

Abstract

In response to the national strategic demand for cultivating talent aligned with New Quality Productive Forces (NQPF), this study aims to reform the educational paradigm of the "Power Electronics Technology" course in higher engineering education. A progressive ideological and pedagogical integration model termed the "Three Teaching Objective, Five Measures, Five Assessments methods, and A calculation method for objective attainment degree." is designed and implemented. This reform was applied to the 2023 grade students of the course, with the 2022 grade serving as a comparison group. The intervention involved restructuring course content, innovating teaching methods, and overhauling the assessment system. The key finding was a 24% increase in the average course attainment degree for the 2023 grsde compared to the 2022 grade, demonstrating the model's effectiveness in enhancing learning outcomes. This study provides a replicable, data-driven reform framework that successfully translates the macro-concept of NQPF into micro-level curricular practice, offering a valuable solution for engineering education innovation in the context of technological and strategic transformation.

Keywords: New quality productive forces, Power Electronics Course, Reform Measures, Teaching Methods, Assessments methods

---

[1] Corresponding Author

Introduction

In September 2023, during a symposium on promoting the full revitalization of Northeast China in the new era, General Secretary Xi Jinping first proposed accelerating the formation of new quality productive forces (NQPF) to enhance new drivers of growth. The Chinese 2024 National Two Sessions placed special emphasis on NQPF, with the conference characterized by an enthusiastic atmosphere and active discussions (Yang, 2024). The essence of NQPF lies in knowledge-driven production, reflecting the output efficiency and level of new production methods (Hongdi, 2025; Xuan, 2025). It is prominently demonstrated in transforming the advantages of scientific and technological innovation resources into developmental strengths (Guozhen, 2024; Pan et al., 2025), which in turn enhances society's capacity to reshape the world and create social wealth (Xing, 2025). Such transformation encompasses the entire society's capability system in constructing new forms of capital, featuring disruptive, integrative, and co-creative attributes. Scientific and technological innovation serves as the core element of NQPF, capable of catalyzing new industries, models, and momentum. Cultivating and developing NQPF requires comprehensively deepening reforms to establish new relations of production that align with it. Simultaneously, it

demands strengthening scientific and technological innovation—particularly original and disruptive innovation—to accelerate the achievement of greater self-reliance and strength in science and technology. Additionally, it necessitates optimizing the virtuous cycle of education, science and technology, and talent, while refining mechanisms for talent cultivation, recruitment, utilization, and rational mobility (Boquan et al, 2025). Against this backdrop, NQPF impose higher demands on engineering education.

Power Electronics Technology is a fundamental course for Motor and Electric Drive Control Systems, Variable Frequency Control Technology, Photovoltaic Power Generation Technology, and Wind Power Generation Technology. It serves as both a specialized foundational course for electrical engineering disciplines and an engineering technology extensively applied in nearly all fields related to electrical energy. Notably, its applications in renewable energy generation and electric vehicles have expanded significantly in recent years (Rui et al, 2025). This course plays a crucial role in cultivating application-oriented talents focused on practical skills, and holds significant importance for advancing NQPF (innovation-driven productivity) in intelligent and green manufacturing.

Analysis of Curriculum System Based on Practice-Based Teaching Reflection

Based on practice-based teaching reflection and using graduates from the New Energy Science and Engineering program at Lanzhou City University as a case study, surveys reveal that the core pain points in the current "Power Electronics Technology" curriculum system lie in: the conflict between "rapid technology iteration" and "slow teaching updates," as well as the imbalance between "deep interdisciplinary integration" and "surface-level knowledge delivery." Traditional Power Electronics courses suffer from outdated content, monotonous teaching methods, weak practical integration, and falling short in cross-disciplinary convergence. Specifically, the "Power Electronics Technology" course exhibits the following critical issues:

Outdated Course Content. The existing teaching materials lag behind technological advancements. The curriculum remains centered on traditional silicon-based devices, with inadequate coverage of the principles, characteristics, and application cases of wide-bandgap semiconductor devices (e.g., silicon carbide (SiC) and gallium nitride (GaN)), which have become the mainstream choice in fields like renewable energy and fast charging. Additionally, textbooks lack in-depth analysis of advanced topologies such as multilevel converters and matrix converters, resulting in a disconnect from industrial demands.

Monotonous Teaching Methods. Current teaching primarily relies on theoretical lectures, with outdated case studies and a lack of interactive models such as flipped classrooms. This passive knowledge acquisition restricts students' innovative thinking. Additionally, there is an absence of diverse teaching forms, including industry expert seminars and corporate field visits, leading to students' vague understanding of technological trends. Under the context of NQPF, teaching methodologies must prioritize ideological education goals and hybrid teaching models integrating multiple approaches.

Insufficient Practical Innovation Capacity. Experimental setups focus predominantly on analog circuit verification, lacking digital validation platforms (e.g., MATLAB/PLECS simulations). Student engagement in innovation

Empowering University Curriculum System Development with China's New Quality Productive Forces: A Case Study of Power Electronics Technology Course

• 3

competitions remains low, and the curriculum fails to delve into advanced topologies like multilevel converters and matrix converters, resulting in a disconnect from industrial demands.

Teaching resources face multiple challenges: slow updates of textbook content, restricted access and integration of new resources, severe shortage of experimental resources, underutilization of virtual simulation tools despite their potential for complex system modeling.

Currently, research on the reform of Power Electronics Technology courses primarily focuses on the innovation of teaching methods (Muhammad & Theresa, 2019; Wei, 2023) and practical teaching (Mingxin Xiao, 2024; Vijaychandra Joddumahanthi, Łukasz Knypiński, Yatindra Gopal, et al., 2025). These studies do not consider the impact of NQPF, lack quantitative validation of comprehensive teaching paradigms, and are deficient in the supervision of quality education objectives within their evaluation methods.

Thoughts on the construction of the curriculum system

The development of NQPF represents a new height in national competitiveness. At its foundation lies the qualitative transformation of laborers, means of labor, and objects of labor, along with their optimized integration; its core is scientific and technological innovation, particularly breakthroughs in original and disruptive technologies. New quality productive forces are not only a direct manifestation of technological innovation but also the core driving force behind high-quality economic development. They emphasize the deep integration of technological innovation, knowledge creation, talent-driven initiatives, and information flow, highlighting the decisive impact of innovative capabilities and comprehensive competencies on national competitiveness. The development of NQPF, represented by artificial intelligence, new energy, and advanced materials, provides value guidance, practice-driven impetus, global perspectives, and technical leverage for cultivating innovative talent. Starting from the "Power Electronics Technology" course, we closely track innovations in the new energy industry and the knowledge advancements in New Energy Science and Engineering, while addressing industry demands for professional competencies in this field.

The development of NQPF imposes higher and more comprehensive requirements on the cultivation of innovative talent in applied universities. The core attributes and curriculum system development must revolve around technological innovation, industrial demands, and interdisciplinary integration. First, it is essential to shape the values of innovative talent. Innovators should possess ideological and ethical literacy centered on correct worldviews, life perspectives, and values. This manifests as deep-rooted patriotism, the spirit of innovation to scale new heights, a truth-seeking attitude, and a selfless dedication to contributions over personal gain. Designing the ideological module in the Power Electronics Technology course must therefore emphasize scientific rigor, commitment to serving national strategic needs, and integrating personal aspirations into the great cause of national rejuvenation. Simultaneously, students must develop a sense of global responsibility and international perspective. Second, interdisciplinary training is crucial to cultivate comprehensive innovative abilities. Amid the rise of new quality productive forces, applied talents with multi-dimensional innovative capabilities—through technological breakthroughs, resource integration, and industrial alignment—become pivotal engines for accelerating scientific achievement translation and leading high-end industrial transformation. They embody the core momentum for building national strategic scientific strength and achieving global competitiveness (Shengchi Liu, Shuangyue Xiao, et al., 2022). Thus, it is necessary to reconstruct the theoretical framework of courses, enabling students to tackle complex problems through multidisciplinary collaboration and deepen their subject-matter expertise. Third, it is imperative to equip students with the capability to solve real-world social problems (Beibei, Yutong, et al., 2024). Practical instruction is a highly effective approach in innovative talent cultivation; it moves beyond theoretical concepts learned in class and applies them to hands-on challenges—enhancing both comprehension and applied skills (Wu Chan, 2022). For this purpose, the practical component of courses must be redefined. Activities such as innovation competitions and entrepreneurship projects spark innovative passion and creativity, ultimately nurturing top-tier applied talents with integrated innovative capabilities. Finally, intelligent methodologies must revolutionize talent cultivation pathways. Generative artificial intelligence, represented by DeepSeek, is triggering a paradigm shift in education (Xi Zhu, 2021). As an advanced smart education platform, generative AI leverages unique technological advantages to: integrate knowledge efficiently, assist instruction dynamically, build cohesive collaborative learning ecosystems, and implement intelligent evaluation mechanisms. This creates powerful support for fostering innovative talent.

We aim to establish an application-oriented teaching system for "Power Electronics Technology" in universities, centered on student outcome capabilities and ultimately focused on enhancing students' practical skills. Under the context of building application-oriented universities, empowered by NQPF, we conduct comprehensive research

on the ideological and political framework, curriculum content, teaching methodologies, educational resources, and assessment methods for the "Power Electronics Technology" course within the New Energy Science and Engineering program.

Thus, we adopt the Power Electronics Technology course as a case study to investigate measures for curriculum system development empowered by new quality productive forces. Based on the cyclical path of "practice-reflection teaching → proposing reform measures → quantitative verification → teaching reflection," we have developed the "Three Teaching Objective, Five Measures, Five Assessments" educational paradigm for the Power Electronics Technology course.

Three Teaching Objective

"Power Electronics Technology" is a core specialized course in Electrical Engineering and New Energy Science and Engineering programs (Sun & Tang, 2022). The teaching objectives include:

(1) Teaching Objective I (TO I): Master the characteristics of power electronic devices, principles of power conversion circuits, and control strategies after completing the course.

(2) Teaching Objective II (TO II): Acquire practical abilities in wiring, testing power conversion circuits, and designing/debugging renewable energy generation systems.

(3) Teaching Objective III (TO III): Cultivate a belief in serving the nation through technology, dedicating themselves to the "dual carbon strategy" (carbon peak and carbon neutrality goals) with a craftsman spirit.

Five Measures for the construction of the curriculum system

Reconstruct the structure of ideological and political education in the curriculum

The cultivation of innovative talents in the new era requires not only solid academic competence and innovative capabilities but also broad international perspectives and a strong sense of social responsibility (Yuhan Xu, Zhiqiang Jin & Rui Zhang, 2025; Huanhuan Xu, Xiaoqing Hu, Quping Zhu, et al., 2025). Under the context of new quality productive forces, the Power Electronics Technology course can integrate theoretical, experimental, and practical education with ideological and moral development. This integration may support students in: grasp the characteristics of power electronic devices; master the working principles, functions, and applications of four types of power conversion circuits; enhance hands-on practical skills to improve employability; atriotic dedication, global perspectives, innovative thinking, and craftsman spirit; Scientific methodologies, critical thinking, and engineering ethics.

This paper establishes "patriotic dedication, ethical responsibility, craftsman spirit, and serving the nation through technology" as core objectives. Aligned with China's national strategic demands for "carbon peak and carbon neutrality" and student cognitive development patterns, it designs a progressive pathway for integrating ideological and political elements. The pathway follows a logical progression: emotional foundation → cognitive deepening → value internalization → practical transformation → belief sublimation. It identifies key themes, including: national pride and scientific curiosity; awareness of technological self-reliance; recognition of national strategies; engineering safety consciousness; responsibility for technological contribution to national development; materialist dialectics; integrity mindset; innovative thinking; scientific rigor; spirit of scientific inquiry; community with a shared future for mankind.

These themes are embedded into course content through online guided learning, case studies, group discussions, summary analysis, extended study, experimental work, simulation design, and project-driven teaching. It anchors the scientist's spirit and employs real-world cases to guide students: from "knowing the nation" to "loving the nation"; from "willingness to act" to "capacity to act". Ultimately cultivating new-era youth with vision, pursuit, responsibility, and capability.

Empowering University Curriculum System Development with China's New Quality Productive Forces: A Case Study of Power Electronics Technology Course

• 5

Optimize the teaching content of the courses

The current teaching content lags behind technological advancements, as courses remain centered on traditional silicon-based devices (such as IGBTs) while inadequately covering the principles, characteristics, and application cases of wide-bandgap semiconductor devices like silicon carbide (SiC) and gallium nitride (GaN)—the latter having become prevailing options in fields like renewable energy and fast-charging technologies. Moreover, the curriculum lacks in-depth analysis of emerging topologies, including multilevel converters and matrix converters, resulting in a divergence from actual industrial requirements and practices.

Under the context of NQPF, curriculum content development must strengthen the integration of cutting-edge technologies, focus on new energy and energy storage applications, and align with intelligent manufacturing. Through this course, students will: master rectification and inversion technologies widely applied in wind and solar power generation systems；acquire fundamental power supply design methodologies; Understand frontier application fields related to power electronics technology. Consequently, the teaching content for "Power Electronics Technology" should be selectively optimized: move away from rigid adherence to a single textbook and avoid exhaustive coverage of all textbook content. adopt a targeted approach by prioritizing topics highly relevant to New Energy Science and Engineering, especially widely adopted industrial practices; incorporate content related to academic competitions and adjust laboratory hours to enhance hands-on training.

In the generation of renewable energy, inversion, DC chopping, and AC frequency modulation are crucial technologies. The use of switches and PWM control techniques is also widely prevalent. Furthermore, these topics often appear as subjects in renewable energy engineering competitions. Therefore, it is essential to enhance theoretical knowledge in these areas.

Adjust the credit hours for the experimental component. As students majoring in New Energy Science and Engineering, they should not focus heavily on the internal structures and operating principles of power electronic devices but rather prioritize their practical applications. Therefore, experiments on power electronic devices will be reduced, while experiments on multilevel converters and matrix converters will be added. Additionally, the three-phase semi-controlled rectification experiment will be replaced with a PWM rectifier circuit experiment.

To enhance students′ innovative practical skills and motivate them to actively contribute to the national strategy of rejuvenating China through science and education, we guide students to align their innovative passion with the needs of national energy development strategies. This supports green and low-carbon energy transition, advances new energy development, and fosters the construction of a Beautiful China, thereby continuously promoting technological innovation among university students. In alignment with our university's training program for the New Energy Science and Engineering major, we organize students to participate in national competitions such as the National Undergraduate Electronic Design Contest, the National Renewable Energy Science and Technology Competition, and the National Energy Conservation and Emission Reduction Social Practice & Technology Competition. Consequently, 8 credit hours of practical content have been added to the Power Electronics Technology curriculum.

To fully mobilize students' enthusiasm and bridge the gap between theoretical knowledge and real-world applications, the practical component integrates cutting-edge case studies:

(1) Rectifier circuits: principles applied in new energy vehicle charging piles, converting AC to DC for EV batteries.

(2) Inversion circuits: technologies used in high-speed train onboard power systems, converting DC to AC for diverse loads.

(3) DC chopper circuits: core mechanisms for EV speed regulation via voltage adjustment.

(4) AC voltage regulation circuits: contactless voltage regulation methods for energy-efficient street lighting. PWM control techniques: switching regulators for precision dimming applications.

Innovate multi-mode blended teaching methods

The current teaching methodology remains predominantly lecture-based, with outdated case studies and a lack of interactive models like flipped classrooms. Students passively receive knowledge, and their innovative capacity development is constrained. There is also an absence of diverse teaching formats, such as inviting industry experts to lectures or organizing field visits to enterprises, leaving students with a vague understanding of technological trends. Against the backdrop of new quality productive forces, the development of teaching methods should place high emphasis on integrating moral education goals through curriculum-based ideological and political education and adopting multimodal blended teaching approaches.
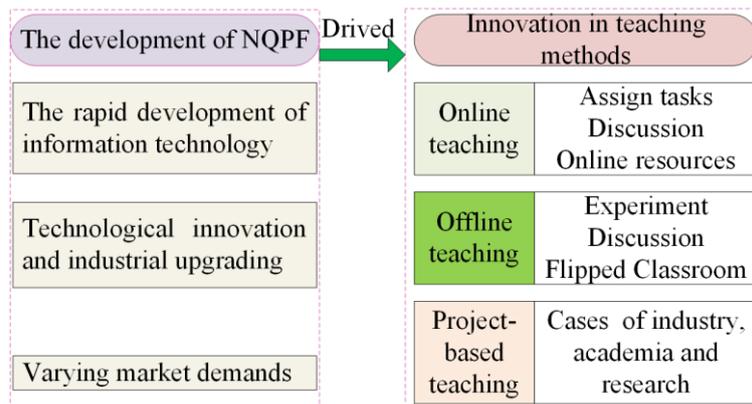
Figure 1. The framework of multi-mode blended teaching

Driven by the development of NQPF, the curriculum integrates cutting-edge case studies, online teaching platforms, and software simulations to establish a multi-modal blended teaching model (Muhammad & Theresa, 2019; Wei, 2023). This model combines online-offline hybrid instruction with integrated theory-practice pedagogy, specifically tailored for students in New Energy Science and Engineering. As illustrated in Figure 1, the redesigned teaching framework is oriented toward ideological and moral education objectives, emphasizing the integration of online and offline learning and the synergy of industry-academia-research collaboration.

Online components includes live-streamed lectures, video courses, and online discussions, providing students with flexible learning time and abundant learning resources; offline components, on the other hand, enhances students' practical abilities and teamwork spirit through classroom lectures, practical activities and seminars. Besides, the flipped classroom is incorporated to enable students to master knowledge through self-study and deepen the interactive sessions in class.

Power electronics is a highly interdisciplinary field that encompasses power conversion, control, and the application of various power electronic devices. To cultivate students' practical skills and innovative thinking, industry-academia-research collaboration is leveraged to integrate real-world case studies into power electronics courses (Huimin Shen & Kangming Liu, 2024). Through the analysis and practical application of real-world cases, students gain intuitive insights into complex theoretical concepts and enhance their problem-solving capabilities (Ke Wang, Fei Li, Shengying Yang et al. ,2024). This paper incorporates case studies closely tied to new energy technologies, such as photovoltaic power generation systems, electric vehicle drive systems, and smart grid control systems, into specific teaching practices.

By selecting photovoltaic power generation systems as a case study, students will learn about the design and optimization methods of PV systems through explanations of their basic structure, operational principles, and control strategies. Through simulation and experimentation, the performance of different control strategies will be validated, enhancing students' comprehension and mastery of photovoltaic power generation systems. Select the electric drive system of electric vehicles as a case study to explain technologies such as motor drive, battery management, and energy regeneration. Through practical case analysis, enable students to understand the design requirements and optimization methodologies for electric vehicle drive systems, and validate the performance of the drive system through experimental or simulation-based approaches. Select the distributed energy management system (DEMS) in smart grids as a case study to explain its structure, functions, and control strategies. Through case analysis and experiments, students will gain insights into the application of power electronics technology in smart grids and enhance their mastery of smart grid technologies.

Empowering University Curriculum System Development with China's New Quality Productive Forces: A Case Study of Power Electronics Technology Course

• 7

The application of case-based teaching methods in Power Electronics courses can effectively enhance students' theoretical knowledge and practical skills. By analyzing real-world cases and conducting experimental operations, students gain a more intuitive understanding of complex theoretical concepts, while cultivating their problem-solving abilities and innovative mindset. In future teaching practices, it is essential to continuously refine and optimize case-based teaching approaches, integrating the latest technological advancements and practical engineering applications. This will lay a solid foundation for cultivating high-caliber professionals in the field of Power Electronics Technology

Through this new multi-modal blended teaching, utilizing comprehensive educational approaches, we aim to meet the diverse learning needs of students, cultivate their innovative capabilities and technological literacy, and focus on their all-round development. This approach helps students achieve comprehensive growth in five dimensions: knowledge, skills, health, practical abilities, and ideological development, enabling them to become outstanding talents with well-rounded moral, intellectual, physical, aesthetic, and labor development, thereby laying a solid foundation for advancing NQPF.

Enrich curriculum resources

The development of teaching resources for the Power Electronics course plays a critical role in the teaching process. The Power Electronics course suffers from textbook content detached from practical applications, outdated experimental equipment, and rigid, unchanging experimental content and teaching cases. Systematic and modernized teaching resources facilitate students' in-depth understanding of theoretical knowledge and enhance their practical capabilities. Under the context of NQPF, to meet the rapidly evolving demands of power electronics technology, a scientific and comprehensive teaching resource system must be established (Doni et al, 2023). This paper explores the development of teaching resources for the Power Electronics course from four aspects: teaching materials, experimental equipment, digital resources, and faculty teams. Building upon existing course materials, experimental equipment (Xin & Yanhui 2020), and digital resources, efforts should focus on strengthening three core libraries: ideological education case library, simulation case library, project-based teaching case library, integrated experimental platform and advanced experimental equipment.

The development of teaching materials encompasses foundational textbooks, specialized textbooks, and supplementary resources. Foundational textbooks serve as the core of teaching resource development, providing systematic and fundamental theoretical knowledge. Priority should be given to texts that comprehensively cover

core components, principles of power electronics technology, and their applications—such as Power Electronics Technology, Fundamentals of Power Electronics, and Modern Power Electronics. These resources, characterized by scientific rigor, systematic structure, and cutting-edge relevance, help students establish a solid theoretical foundation. Specialized textbooks focus on in-depth research and applications within specific domains, including renewable energy generation systems, electric vehicle drive technologies, and smart grids. Academic teams may author subject-specific texts (e.g., New Energy Power Electronics Technology or Power Electronics for Electric Vehicles) that integrate the latest technological advancements, enabling students to master advanced knowledge in specialized fields. Supplementary resources encompass practical case repositories, experimental guidebooks, and technical application references, such as Power Electronics Experiment Manuals and Case Studies in Power Electronics Applications. These materials deliver rich practical resources to familiarize students with experimental operations and real-world applications of power electronics technology.

The construction of experimental facilities includes basic experimental equipment, comprehensive experimental platforms and advanced experimental equipment. Basic experimental equipment is used for fundamental experiments and theoretical verification, including power electronic device testers, circuit workbenches, and basic testing instruments (such as oscilloscopes, ammeters, and voltmeters). These devices support the design, construction, and testing of fundamental power electronic circuits, helping students master essential experimental skills. Strengthen the construction of comprehensive experimental platforms and advanced experimental equipment. The comprehensive experimental platform is used for comprehensive experiments and system design, equipped with power converters, inverters, rectifiers, DC converters and corresponding control systems, which support the experiments and debugging of complex power electronic systems and cultivate students' comprehensive design abilities. The advanced experimental equipment is used for the research of cutting-edge technologies and new applications, including new energy power generation simulation devices, smart grid experimental platforms and electric vehicle power system experimental platforms. Through these devices, students can conduct experiments related to new energy and smart grids, simulate actual application scenarios, and enhance their understanding and mastery of cutting-edge technologies.

The development of digital resources should also encompass online courses, virtual simulation experiments, digital textbooks, and resource databases. Online courses provide flexible and diverse learning pathways for students through MOOC platforms and university-owned online learning platforms. They cover foundational courses, specialized curricula, and cutting-edge technical topics in Power Electronics Technology. Online courses facilitate self-directed learning and knowledge consolidation. Virtual simulation experiments offer safe and repeatable experimental environments using simulation software such as MATLAB/Simulink, PSIM, and PSpice. They support the modeling, simulation, and analysis of power electronic circuits and systems. Through virtual experiments, students can design and debug complex systems in simulated settings. Digital textbooks and resource databases enable students to access learning materials anytime, anywhere, including e-books, courseware, video tutorials, lab manuals, and relevant research papers. Such resources are delivered via university digital libraries and academic resource databases, providing students with rich learning materials. This integrated approach ensures resource development meets evolving educational demands while fostering innovation and practical competency in power electronics education.

Teacher team development encompasses the construction of professional faculty, dual-qualified teachers, and teaching teams. Professional faculty development focuses on advancing subject-matter expertise through specialized training and academic collaborations (Jiajia Yuan, Sike Wang & Jingsi Gao, 2025). Dual-qualified teachers combines theoretical proficiency with practical industry experience. Teachers engage in enterprise internships, obtain vocational certifications, and participate in industry-academia projects to bridge theory-practice gaps. Teams adopt modular teaching methods and competency-based assessments, improving student readiness for industry certifications.Teaching team development aims to enhance overall instructional quality and research capabilities. By regularly organizing teacher training, academic exchanges, and part-time positions in enterprises, educators stay abreast of cutting-edge technological trends and industry demands, thereby promoting the organic integration of teaching and research. Industry-driven projects lead to patents and curriculum upgrades. This integrated approach ensures teacher teams remain dynamic, industry-relevant, and pedagogically innovative.

Build cases of ideological and political education in courses. To address various ideological education themes, we have designed the following case studies for the "Power Electronics Technology" course: applications in renewable energy, CRRC's high-power IGBT, west-east electricity transfer project, charger design innovations, ultra-high voltage transmission projects, comparative analysis of chopper circuit characteristics, voltage-regulated motor speed control systems, cumulative nature of technological breakthroughs, rigorous experimental processes, simulation designs for cutting-edge challenges, and renewable energy's role in global climate governance. These ideological and political cases should be subtly integrated into the course content through methods such as pre-class online guidance, classroom case introduction, classroom case discussion, classroom summary analysis, post-class extension learning, post-class experiments, post-class simulation design, and project-driven teaching.

Enrich simulation cases. Although tools like MATLAB/Simulink can compensate for the limitations of physical experiments, the current simulation case library remains underdeveloped and loosely integrated with the curriculum. Building upon existing simple circuit simulation cases, we propose incorporating practical application systems — such as smartphone chargers and electric vehicle charging stations — through interdisciplinary integration, and systematically embedding these into the core teaching framework.

To construct project-based teaching cases, we integrate hotspot industrial applications into project-based learning. For instance, in the rectification circuit, knowledge about new energy electric vehicle charging stations is introduced to convert alternating current into the direct current required by the batteries of new energy vehicles; in the inverter circuit, knowledge about the on-board power supply for high-speed rail is incorporated to convert direct current into alternating current of different amplitudes needed by various loads; in the DC chopping circuit, core knowledge of electric vehicle speed regulation, namely the adjustment of power supply voltage magnitude, is introduced; in the AC voltage regulation circuit, the contactless voltage regulation method of energy-saving street lamps in practice is introduced; in the PWM control technology section, a switch regulator is introduced for dimming.

Five Assessments methods

To evaluate students' learning outcomes and competencies, diversified and scientifically sound performance assessment methods should be established (Zhao, 2021). Under the context of NQPF, this study adopts multidimensional evaluation methods to comprehensively and objectively assess students' integrated competencies

Empowering University Curriculum System Development with China's New Quality Productive Forces: A Case Study of Power Electronics Technology Course

• 9

and skill levels. Aligned with the restructured curriculum goals and generative AI technology (Jia, 2025), we shift toward a talent cultivation-oriented evaluation philosophy, promoting cultivation through evaluation, and leveraging comprehensive competency assessment to drive innovative talent development. The evaluation framework encompasses multiple dimensions: knowledge mastery, practical skills, innovative capabilities, interdisciplinary competence, team collaboration, ethical and social responsibility, global perspectives.

This paper has established an intelligent evaluation index system. The proportions of knowledge goals, ability goals, and quality goals are 50%, 30%, and 20% respectively. The more detailed process-based assessment methods encompass five key aspects: class discussions, specialized reports, simulation experiments, hands-on laboratory experiments, and theoretical examinations. The objectives, format, content requirements, percentages, and supported teaching objectives of each assessment method are shown in Table 1.

Table 1. Diversified assessment methods

Assessment methods	Objectives	Format	Content requirements	Percentage	Supported teaching objectives
Class discussions	By discussing hot topics, cultivate students' conviction in serving the country through science and technology.	Classroom discussions and study notes.	This includes the students' interaction during class, their contributions in group discussions, and the completion of class assignments.	20%	TO III
Specialized reports	Assessing students' topic engagement and teamwork spirit.	Production and presentation of the special report PPT.	Self-study content, division of labor details, writing of special reports, and creation of PPTs.	10%	TO II
Simulation experiments	Assess students' understanding and design capabilities for power electronic systems through computer simulation software.	Simulation model presentation, simulation result analysis and reports	Using simulation tools such as MATLAB/Simulink, the working process of the actual power electronic system can be simulated.	10%	TO II
Hands-on experiments	Assess students' hands-on skills, experimental design ability, and analysis skills of experimental results.	Experimental reports, experimental operation examinations, experimental design plans.	Experimental principles, experimental procedures, data processing, and analysis of experimental results, etc.	10%	TO II
Theoretical examinations	Assess students' mastery of fundamental concepts, principles, and theoretical knowledge.	Test paper	Basic knowledge, formula derivation, short-answer questions, drawing questions and calculation questions.	50%	TO I

The scores for classroom discussions are derived from observation and note-taking scores, those for specialized reports and simulation experiments come from document analysis, scores for hands-on laboratory experiments are based on observation, and scores for theoretical examinations are derived from achievement scores. Assume that a student's grades for the theoretical examination, hands-on experiment, simulation experiment, thematic report, and class discussion are A1, B1, B2, B3, and C1 respectively. The achievement degree of each teaching objective for this student can be calculated using the mathematical expression below.

$$r_1 = \frac{A1 \times 0.5}{50} \tag{1}$$

$$r_2 = \frac{B1 \times 0.1 + B2 \times 0.1 + B3 \times 0.1}{30} \tag{2}$$

$$r_3 = \frac{C1 \times 0.2}{20} \tag{3}$$

Where r_1 is the achievement degree of TO I, r_2 is the achievement degree of TO II, and r_3 is the achievement degree of TO III. The overall objective achievement degree can be calculated using Equation (4). The value of r determines the achievement degree of students regarding the teaching objectives. A value closer to 1 indicates better fulfillment, while a value less than 0.6 signifies failure to meet the target.

$$r = r_1 \times 0.5 + r_2 \times 0.3 + r_1 \times 0.2 \tag{4}$$

The main feature is that generative AI is incorporated in the evaluation of students' abilities. AI is used to record learning trajectories and quantify non-cognitive indicators such as classroom participation and cooperation ability. Especially in the evaluation of quality abilities, the use of generative AI can more objectively evaluate students' teamwork, ethical and social responsibility, and international perspective. Through this measure, the key abilities that students should possess can be comprehensively understood and evaluated, providing solid support for innovative talents for their career development and the continuous progress of the industry. Meanwhile, this research adopts a prudent, innovative, and responsible approach to the application of generative AI, firmly keeping the steering wheel of assessment and the initiative of value judgment in the hands of teachers. It strives to leverage cutting-edge technological achievements while upholding the educational essence of evaluation and the integrity baseline of academic research.

Analysis of the effectiveness of curriculum construction

The students from both 2022 and 2023 grades of the New Energy Science and Engineering program at Lanzhou City University are labelled as example, the effective of the newly proposed curriculum system is analyzed in this study. Class 221 (2022 grade, 50 students) adopted the old curriculum system, while Class 231 (2023 grade, 45 students) adopted the proposed curriculum system in this paper, while all other conditions remained consistent. Classes 221 and 231 were taught by the same teacher. For the five assessment components, the overall objective achievement degree of each student was calculated using Eqs. (1)~(4). The objective achievement degrees for Classes 221 and 231 are illustreated in Figure 2 and Figure 3, respectively.

The average objective achievement degree of each class was calculated. It was found that the average achievement degree of Class 231 increased by approximately 24% compared to that of Class 221. As shown in Figure 3, over 94% of the 2023 cohort achieved strong objective attainment, while 6% attained moderate results. The distribution points of individual attainment in Figure 3 are densely clustered, indicating that after the curriculum system construction of "Power Electronics Technology" was empowered by NQPF, students have a better grasp of the overall course content, and students' overall capabilities have been enhanced.
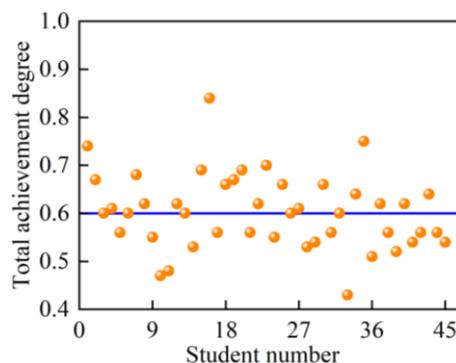

Figure 2. Course total attainment degrees for the 2022 grade

Empowering University Curriculum System Development with China's New Quality Productive Forces: A Case Study of Power Electronics Technology Course
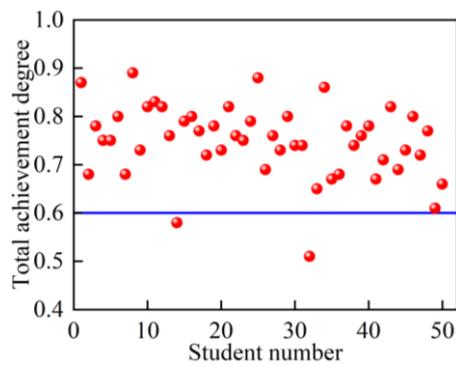
• 11

Figure 3. Course total attainment degrees for the 2023 grade

Through the implementation of curriculum-based ideological and political education, the class engagement and competition award rates of the 2023 grade have improved. The penetration rate of renewable energy-related topics in self-study reports has also increased. Survey results indicate that 90% of students expressed willingness to pursue careers in national key fields such as new energy and power grids within their capabilities. This demonstrates that, by aligning with the development of China's NQPF and through measures such as restructuring teaching content, innovating teaching methods, enhancing teaching resources, and improving assessment methods, the quality of student cultivation has been effectively enhanced.

The implementation of this project have enhanced students' proficiency in using simulation software and potentially stimulated their active engagement in disciplinary competitions and practical projects. This engagement correlated with the development of diverse technology-driven works aligned with course objectives. Throughout this process, students demonstrated solid professional knowledge and strong ideological-political literacy. Their participation in competitions may have contributed to both outstanding outcomes and a deeper understanding of specialized knowledge, while also reinforcing their commitment to ideological education. These accomplishments may be interpreted as an indicator of students' individual capabilities, offering preliminary support for the role of new quality productive forces in empowering the Power Electronics Technology curriculum system.

Conclusion

The course "Power Electronics Technology" plays a crucial role in cultivating talent for the new energy sector. In alignment with the development of China's NQPF, this paper aims to reconstruct the educational paradigm of the "Power Electronics Technology" course. Building upon three teaching objectives, it proposes five teaching reform measures, five assessment methods, and a calculation method for objective attainment. Through anchoring industrial demands, driving with digital and intelligent technologies, and promoting interdisciplinary integration, it achieves comprehensive innovation across the entire chain from course content to evaluation methods.

We implemented the new curriculum system for the 2023 grade of students. Compared to the 2022 grade, which used the old curriculum system, the average course attainment degree for the 2023 grade increased by 24%. Through the implementation of curriculum-based ideological and political education, the class engagement and competition award rates of the 2023 grade have improved. The penetration rate of renewable energy-related topics in self-study reports has also increased. Survey results indicate that 90% of students expressed willingness to pursue careers in national key fields such as new energy and power grids within their capabilities. This demonstrates that, by aligning with the development of China's NQPF and through measures such as restructuring teaching content, innovating teaching methods, enhancing teaching resources, and improving assessment methods, the quality of student cultivation has been effectively enhanced.

In future teaching practices, we will continuously optimize the teaching content of the "Power Electronics Technology" course and explore innovative pedagogical approaches aligned with technological development needs. Simultaneously, we will refine and innovate the teaching resource system to provide robust support for cultivating power electronics professionals. Furthermore, we will integrate cutting-edge technologies and educational philosophies to enhance course evaluation methods, deepen the application of AI large models in teaching, dynamically update cutting-edge cases such as "energy transition" and "intelligent manufacturing," and drive the continuous improvement and innovation of the course evaluation system. This reform paradigm can be extended to more universities, offering a replicable Chinese solution for engineering education.

Author (s) Contribution Rate

The first author contributed 80%, the second author 10%, and the third author 10%.

Ethical Approval

For this study, approval was received from the Lanzhou City University Educational Sciences Ethics Committee with the decision numbered 2025/1 and dated 06/03/2025.

Empowering University Curriculum System Development with China's New Quality Productive Forces: A Case Study of Power Electronics Technology Course

• 13

References

Boquan Zhang, Ling Zhang & Zongfeng Song. (2025). Research on New Quality Productive Forces in Education. *Open Journal of Social Sciences*, 13(09), 632-642. https://doi.org/10.4236/JSS.2025.139038

Beibei Liu, Yutong Li, Yuxi Liu, Jiaqi Hao & Jiaxin Wang. (2024). Exploration of the "Class-Competition-Training" Trinity Model of Cultivating Applied Business Talents and Practice. *Curriculum and Teaching Methodology*, 7(5), https://doi.org/10.23977/CURTM.2024.070513.

Doni Tri Putra Yanto, Hastuti, Hermi Zaswita, Maryatun Kabatiah, Sukardi & Ambiyar. (2023). Validity Test Analysis of Virtual Laboratory-Based Job Sheet for Power Electronics Course. *International Journal of Information and Education Technology*, 13(9). https://doi.org/10.18178/IJIET.2023.13.9.1951.

Guozhen Hua, Fanlong Zeng & Huaping Sun. (2024). Analyzing New Quality Productive Forces in New Energy Vehicle Companies Based on a New Multi-Criteria Decision Analysis Model. *World Electric Vehicle Journal*, 15 (11), 503-503. https://doi.org/10.3390/WEVJ15110503.

Huimin Shen & Kangming Liu. (2024). Exploration and Practice of Mutual Integration and Promotion of Scientific Research and Teaching in the Context of Undergraduate Talent Cultivation of "Engineers with Excellence"—Local Applied Research Universities as an Example. *Curriculum and Teaching Methodology*, 7 (8), https://doi.org/10.23977/CURTM.2024.070818.

Huanhuan Xu, Xiaoqing Hu, Quping Zhu & Li Gao. (2025). Practice and Exploration of Teaching Reform in the Engineering Mechanics Course under the Deep Integration of the "Outcome-Based Education Concept" and Curriculum-Based Ideological and Political Education. Journal of Contemporary Educational Research, 9(11), 284-291. https://doi.org/10.26689/JCER.V9I11.12944.

Hongdi Zhao, Hengtong Qu, Yishu Yan, Yahui Shan, Haoli Tian, Yulian Liu & Xueyou Feng. (2025). Research on the Path of Innovation and Entrepreneurship Education for Chinese Materia Medica Programs Oriented toward the Development of New Quality Productivity: A Case Study of Hainan Higher Education Institutions. *New Explorations in Education and Teaching*, 3(9), https://doi.org/10.70711/NEET.V3I9.7768.

Jia Wu. (2025). AIGC Technology Enabling Innovative Approaches in Visual Design of Online Learning Resources. *Journal of Contemporary Educational Research*, 9(8), 348-351. https://doi.org/10.26689/JCER.V9I8.12044

Jiajia Yuan, Sike Wang & Jingsi Gao. (2025). Exploration and Practice of Cultivating High-Level Talents in Water Environment Monitoring and Treatment through the Integration of Posts, Courses, Competitions, and Certifications. *International Journal of Learning and Teaching*, 11(1), https://doi.org/10.18178/IJLT.11.1.34-38.

Ke Wang, Fei Li, Shengying Yang & Yali Luo. (2024). Exploration and Practice of Teaching Research and Reform on Echelon-Based Applied Talent Cultivation in the View of Industry-Education Integration. *International Journal of Learning and Teaching*, 10(5), https://doi.org/10.18178/IJLT.10.5.647-651.

Muhammad Hafiz & Theresa Kwong. (2019). A structured, multi-mode professional development programme on blended learning and its influences on the participants' TPACK. *Int. J. of Smart Technology and Learning*, 1(3), 267-280. https://doi.org/10.1504/IJSMARTTL.2019.099517.

Mingxin Xiao. (2024). Application of Power Electronics Technology in Renewable Energy Systems. Studies in Social Science Research, 5(2). https://doi.org/10.22158/SSSR.V5N2P157.

Pan Liu, Dong Li & Weilin Nie. (2025). Measurement and Spatiotemporal Evolution Analysis of New Quality Productive Forces in China's Manufacturing Using TOE Theory. *Engineering Letters*, 33(9).

Rui Yang, Xianglu Jin, Wenhui Huang & Sike Wang. (2025). Evolutionary game analysis of the driving mechanism for green technology innovation in enterprises: a new quality productive forces perspective. *Finance Research Letters*, 85 (PD), 108115-108115. https://doi.org/10.1016/J.FRL.2025.108115.

Shengchi Liu, Shuangyue Xiao, Xinchen Zhang & Li Liu. (2022). Exploration and Practice of Joint Cultivation Model of University-Enterprise Laboratory for Information Applied Talents under the Background of Deep Integration of Industry-University-Research. *International Journal of New Developments in Education*, 4(13), https://doi.org/10.25236/IJNDE.2022.041311

Sun Yan & Tang Tao. (2022). Research on the Teaching Reform of Ideological and Political Education Introduced into the Course of Power Electronic Technology. *Adult and Higher Education*, 4(12), https://doi.org/10.23977/ADUHE.2022.041207

Vijaychandra Joddumahanthi, Łukasz Knypiński, Yatindra Gopal & Kacper Kasprzak. (2025). Review of Power Electronics Technologies in the Integration of Renewable Energy Systems. Applied Sciences, 15(8), 4523-4523. https://doi.org/10.3390/APP15084523.

Wu Chan. (2022). Research on the Internationalization Strategy of Higher Education under the Background of Network Education. *Applied bionics and biomechanics*, 2022, 9352275-9352275. https://doi.org/10.1155/2022/9352275.

Wei Liang. (2023). Research on Online Teaching and Offline Course Construction for Power Electronics. *Journal of Contemporary Educational Research*, 7(3), https://doi.org/10.26689/JCER.V7I3.4804.

Xuan Lei. (2025). On New Quality Productivity: Equal Emphasis on Efficiency and Quality under the Transformation of Management Thought. *Forum on Research and Innovation Management*, 3(10). https://doi.org/10.70711/FRIM.V3I10.7509.

Xing Li, Zhu Zhu, Dan Yang & Zimin Liu. (2025). The impact of power marketization reform on new quality productive forces: An improved overall method. *Energy*, 334, 137820-137820. https://doi.org/10.1016/J.ENERGY.2025.137820.

Xin Tang & Yanhui Xi. (2020). Application of hardware-in-loop in teaching power electronic course based on a low-cost platform. *Computer Applications in Engineering Education*, 28(4), 965-978. https://doi.org/10.1002/cae.22274.

Yang Xu. (2024). The Connotation of New Quality Productive Forces in Higher Education: A Perspective Based on the Three Elements of Productive Forces. *Evaluation of Educational Research*, 2(11). https://doi.org/10.70711/EER.V2I11.7739.

Yuhan Xu, Zhiqiang Jin & Rui Zhang. (2025). Application and Practice of Curriculum Ideological and Political Concepts in the Course "Municipal Road Engineering Construction". Education Reform and Development, 7(11), 141-148. https://doi.org/10.26689/ERD.V7I11.13075.

Xi Zhu. (2021). Research on the Reform of Higher Automotive Engineering Education Under the Background of Artificial Intelligence. *E3S Web of Conferences*, 245, 03091-. https://doi.org/10.1051/E3SCONF/202124503091

Zhao Guopeng. (2021). Effect analysis of the teaching method of mutual result correction between students in an experiment of power electronics course. *IET Circuits, Devices & Systems*, 16(3), 201-209. https://doi.org/10.1049/CDS2.12096.

AI-Facilitated Self-Directed Learning and Mathematics Performance: A Mixed-Methods Study on ChatGPT Use among Generation Z Students

Jhoname Besas[1] | ![ORCID] | jbesas1@ssct.edu.ph
Surigao del Norte State University, Graduate School Department, Surigao City, Philippines
Louida Patac | ![ORCID] | lpatac@ssct.edu.ph
Surigao del Norte State University, Graduate School Department, Surigao City, Philippines
Adriano Patac Jr. | ![ORCID] | apatac@ssct.edu.ph
Surigao del Norte State University, Graduate School Department, Surigao City, Philippines

Abstract

The rapid adoption of generative artificial intelligence (AI) tools such as ChatGPT has raised important questions about how AI-supported learning relates to students' self-directed learning (SDL) and mathematics achievement, particularly among Generation Z learners. This study examined the relationship between AI-facilitated SDL and mathematics performance using a convergent mixed-methods design among junior high school students in accredited public schools in the Philippines. A total of 272 Grade 7–10 students completed the Self-Rating Scale of Self-Directed Learning (SRSSDL) and an AI/ChatGPT Use and Engagement questionnaire, and their responses were linked to standardized mathematics assessment scores. In addition, 73 students participated in focus group discussions to describe how they used ChatGPT for mathematics learning. Quantitative results showed that most students demonstrated moderate SDL readiness (47.79%), while 29.41% exhibited high SDL and 22.79% showed low SDL. SRSSDL scores were strongly and positively correlated with mathematics performance ($r = .849$, $p < .001$), whereas ChatGPT usage showed a weak but significant positive correlation with performance ($r = .227$, $p < .001$). SRSSDL and ChatGPT usage were not significantly related ($r = .080$, $p = .187$). Multiple regression indicated that SDL readiness and ChatGPT usage significantly predicted mathematics performance ($R^2 = .746$), with SDL emerging as the dominant predictor ($\beta = .836$, $p < .001$) and ChatGPT usage contributing a smaller but significant effect ($\beta = .159$, $p < .001$). Qualitative thematic analysis yielded three themes: (1) Personalized support and motivation, (2) Challenges in critical thinking and overreliance, and (3) ChatGPT as a learning companion, indicating that the benefits of ChatGPT depend on how intentionally and critically it is used. Integrated findings suggest that while ChatGPT may provide supplementary support, SDL readiness remains the primary driver of mathematics achievement, and responsible AI use practices are necessary to minimize risks such as overreliance and reduced independent reasoning.

Keywords: Self-directed learning, ChatGPT, Generation Z, Mathematics education, AI in education, Mixed-methods

---

[1] Corresponding Author

Introduction

The rapid advancement of artificial intelligence (AI) and digital technologies is transforming how education is delivered and experienced, with tools such as ChatGPT providing learners instant feedback, adaptive support, and access to vast information resources across formal and informal learning contexts (Singh et al., 2024). In mathematics education, AI integration has been promoted for its capacity to personalize instruction, streamline repetitive tasks, and respond to learners' questions in real time (Harry & Sayudin, 2023; Zreik, 2024). However, despite increased adoption, the impact of AI on mathematics learning outcomes remains debated, with limited consensus on whether these tools produce meaningful gains in mathematical understanding beyond increased engagement and convenience (How & Hung, 2019; Ali et al., 2023; Ní Shé et al., 2023). This concern is especially salient given that many learners continue to struggle with higher-order competencies such as reasoning and problem-solving, suggesting that technology alone may be insufficient to address persistent learning difficulties (Maskar et al., 2023). At the same time, these developments intersect with the learning profile of Generation Z—often characterized as digitally native students who are highly comfortable with online platforms and inclined toward self-directed learning (SDL), where they seek information independently and learn at their own pace (Gabrielova & Buchko, 2021; Lee et al., 2015; Dimock, 2019; Shatto & Erwin, 2016; Pousson & Myers, 2018). Their near-constant online presence further indicates strong tendencies toward self-initiated learning behaviors, positioning AI tools like ChatGPT as increasingly embedded in their academic routines (Anderson & Jiang, 2018).

Against this backdrop, AI tools have been widely viewed as supports for SDL because they can offer personalized feedback, adaptive practice, and step-by-step guidance—features that align with independent learning preferences in cognitively demanding subjects like mathematics (Darmayanti, 2024). Yet, research also warns that without sufficient guidance and self-regulation, students may develop patterns of overreliance that encourage surface-level engagement rather than deep learning, raising questions about whether AI-supported SDL cultivates genuine mathematical understanding or simply facilitates task completion (Ali et al., 2023; Ní Shé et al., 2023; Banitt & Van Leeuwe, 2013). These questions are particularly urgent in contexts such as the Philippines, where international assessments continue to show persistent challenges in mathematics achievement, including low performance in PISA 2022 and TIMSS 2019 (Foster & Schleicher, 2022; Orbeta & Pacqueo, 2022; Olesco et al., 2024). Consequently, the present study, AI-Facilitated Self-Directed Learning and Mathematics Performance: A Mixed-Methods Study on ChatGPT Use Among Generation Z Students, examines how junior high school Gen Z learners engage with ChatGPT as part of their independent study routines and investigates whether such engagement supports deeper conceptual understanding and improved mathematics performance or primarily serves as a shortcut for completing tasks.

Review of Related Literature

Self-directed learning as a foundation for independent mathematics learning

Self-directed learning (SDL) is commonly framed as learners' capacity to take initiative in diagnosing learning needs, setting goals, selecting strategies and resources, monitoring progress, and evaluating outcomes—processes that are particularly important in mathematics where sustained practice and self-monitoring are essential for mastery. A widely used instrument for operationalizing SDL is Williamson's Self-Rating Scale of Self-Directed Learning (SRSSDL), which was developed and tested as a structured measure of SDL skills and dispositions (Williamson, 2007). Validation work has further examined the SRSSDL's factor structure and provided evidence supporting its use as a practical measure of SDL dimensions (e.g., awareness, learning strategies, learning activities, evaluation, and interpersonal skills), strengthening its relevance for studies that treat SDL as a measurable learner attribute connected to academic outcomes (Cadorin et al., 2013).

Generative AI and ChatGPT in education: opportunities and unresolved concerns

The release and rapid diffusion of generative AI systems—especially ChatGPT—has accelerated research on AI-supported learning, with reported opportunities including on-demand explanations, feedback, idea generation, and personalized support. UNESCO's global guidance emphasizes that generative AI can expand learning support but also raises major concerns related to ethics, privacy, assessment integrity, bias, and the need for human-centered and policy-guided implementation (UNSECO, 2026). Consistent with this, recent systematic reviews of ChatGPT in education synthesize emerging evidence showing broad applications (tutoring-like support, writing/feedback assistance, instructional planning), while also highlighting risks such as hallucinations, academic misconduct,

unequal access, and inconsistent learning benefits depending on how the tool is used and scaffolded (Munaye et al., 2025).

ChatGPT in mathematics learning: tutoring potential but mixed evidence on performance gains

In mathematics education, ChatGPT is increasingly explored as a "tutor-like" support that can provide worked explanations and conversational guidance. Recent classroom-based research in high school mathematics (e.g., learning quadratic functions) illustrates how ChatGPT may be integrated into instruction to support learning tasks and discussion, often reporting positive engagement and instructional possibilities (Trocado et al., 2025). However, the broader literature remains cautious: while AI tools can improve access to explanations and support practice, evidence is still developing on whether such use reliably produces *improvements in mathematical performance* and *deep conceptual understanding*—especially when students may use AI outputs as shortcuts rather than as prompts for reasoning (Munaye et al., 2025.

Risks relevant to "AI-facilitated SDL": automation misuse, overreliance, and shallow processing

A critical thread in human–automation research warns that users may **misuse** automation—over-trusting outputs even when they are incorrect—especially when monitoring is reduced or when systems appear authoritative. Parasuraman and Riley's framework ("use, misuse, disuse, abuse") remains foundational for understanding how automated aids can unintentionally shift users toward complacency and reduced verification (Parasuraman & Riley, 1997). Recent education-adjacent evidence also suggests that overreliance on ChatGPT recommendations can persist even after short AI-literacy interventions; for instance, a randomized study with high school seniors found substantial adoption of incorrect ChatGPT suggestions in problem-solving contexts (reported as a preprint), underscoring that "knowing the limitations" may not automatically translate into better judgment during use (Puppart & Aru, 2025). These findings are directly relevant to SDL because effective self-directed learning depends on metacognitive monitoring and evaluation—skills that can be weakened when learners outsource reasoning or accept answers without verification.

Generation Z learners and digital learning behaviors

Generation Z is frequently described as a cohort shaped by pervasive digital technology and internet-based information access. Pew Research Center's generational framing marks Gen Z as those born from 1997 onward, making them the first cohort to move through schooling in an environment of ubiquitous online tools (Geiger, 2025). In parallel, national survey data on teens' technology use highlight heavy engagement with online platforms and digital communication—conditions that can normalize quick information seeking and tool-mediated learning behaviors (Anderson & Anderson, 2024). This learning ecology helps explain why ChatGPT can become embedded in students' independent study routines, making it important to examine not only frequency of use but also *how* learners use it for explanations, checking solutions, generating steps, or replacing effort.

The urgency of strengthening mathematics learning in low-performing contexts

International assessment results underscore persistent challenges in mathematics achievement in the Philippines. The OECD's PISA 2022 country note reports very low proportions of top performers in mathematics and highlights systemic factors associated with performance differences (*PISA 2022 Results (Volume I)*, 2023). Complementary reporting on TIMSS 2019 likewise indicates very low average performance among Filipino learners at the primary level, reinforcing the need for interventions that strengthen foundational and higher-order mathematical competencies (Ornedo, 2020). Within this context, AI-supported learning approaches are attractive—but they require evidence showing whether they genuinely improve understanding and achievement rather than merely increasing completion and convenience.

Synthesis and RRL implication for the present study

Taken together, the literature suggests that ChatGPT has plausible value as an on-demand support that *could* align with SDL (planning, strategy use, self-checking, evaluation). Yet, major uncertainties remain regarding whether AI use actually strengthens the SDL processes that matter for mathematics performance, or whether it introduces patterns of overreliance consistent with known human–automation risks. This supports the need for a mixed-methods approach that links (1) measurable SDL dimensions and ChatGPT engagement patterns with (2) mathematics performance outcomes, while also documenting learners' real-use behaviors and decision-making

during AI-assisted study—particularly among Generation Z students in contexts where mathematics achievement remains an urgent concern.

Method

Research Design

This study employed a convergent mixed-methods design in which quantitative and qualitative data were collected during the same period, analyzed separately, and then integrated to generate a more comprehensive understanding of the relationship between AI-facilitated self-directed learning (SDL) and mathematics performance among Generation Z students. The quantitative strand used a non-experimental correlational design to examine associations between SDL readiness (SRSSDL), AI/ChatGPT use patterns, and standardized mathematics assessment scores. The qualitative strand used focus group discussions (FGDs) to explore how students use ChatGPT for mathematics learning, including perceived benefits, challenges, verification practices, and possible overreliance. Integration occurred during interpretation through comparison of quantitative trends and qualitative themes.

Sampling and Participants

The study was conducted in accredited public junior high schools in the Philippines during March–April 2024. The sampling frame comprised learners currently enrolled in Grades 7–10 who had completed school-based mathematics assessments. A pragmatic purposive sampling approach was implemented across intact sections with the cooperation of school administrators and teachers. The study focused on learners who reported prior or current use of AI tools (e.g., ChatGPT) for mathematics study, screened in-class using a brief item.

Eligibility criteria included: (a) parental/guardian consent and student assent; (b) ability to complete surveys in English/Filipino; (c) willingness to link survey responses to school mathematics test scores; and (d) attendance during the data-collection window. Students whose mathematics scores could not be matched to survey IDs or who lacked consent/assent were excluded. Learners with SPED needs and accommodations were included when consent was provided and appropriate supports were available.

A total of N = 272 students met inclusion criteria and completed the quantitative survey battery. Participant characteristics are summarized in Table 1. For the qualitative strand, 73 students volunteered and were organized into FGDs of 6–10 participants to encourage interaction and depth. Because sampling purposively targeted students who already use AI for mathematics, the sample was appropriate for examining AI-supported SDL in relation to outcomes but was not designed to estimate the prevalence of AI use among all learners.

Table 1. Descriptive characteristics of survey participants and FGD volunteers

Variable	Category	Survey participants (N=272) n (%)	FGD volunteers (n=73) n (%)
Grade level	Grade 7	78 (28.7)	22 (30.1)
	Grade 8	70 (25.7)	19 (26.0)
	Grade 9	66 (24.3)	17 (23.3)
	Grade 10	58 (21.3)	15 (20.5)
Sex	Female	160 (58.8)	44 (60.3)
	Male	112 (41.2)	29 (39.7)
Age	Range	12–16	12–16
	Mean (SD)	14.1 (1.1)	14.2 (1.1)

AI use (math study)	Prior ChatGPT use	239 (87.9)	69 (94.5)
Other AI tools*	Photomath	122 (44.9)	38 (52.1)
	Google Gemini/Bard	76 (27.9)	22 (30.1)
	Microsoft Copilot	49 (18.0)	13 (17.8)

*Multiple responses allowed; percentages may exceed 100%.

Instruments

Self-Directed Learning Readiness (SRSSDL)

Students' readiness for self-directed learning was assessed using the Self-Rating Scale of Self-Directed Learning (SRSSDL) developed by Williamson (2007). The SRSSDL measures initiative, independence, and responsibility in managing one's learning. Total scores range from 60 to 300, categorized as: Low SDL (60–140), Moderate SDL (141–220), and High SDL (221–300) (Table 2). Higher scores indicate stronger readiness for SDL. The SRSSDL has demonstrated strong internal consistency (Cadorin, Williamson, & Seewoodhary, 2017) and acceptable content validity (Williamson, 2007).

Table 2. Self-Directed Learning Readiness Score Categories

Overall Self-directed Learning Readiness Score

Ranges	Level	Interpretation
60-140	Low	Guidance is needed from the instructor. Any specific changes necessary for improvement must be determined and a possible restructuring of the methods of learning identified.
141-220	Moderate	This range is half-way to becoming a self-directed learner. Areas for improvement must be identified and evaluated, and a strategy adopted with instructor guidance when necessary.
221-300	High	This range indicates effective self-directed learning. The goal is to maintain progress by identifying strengths and methods for consolidation of the student's effective self-directed learning.

The SRSSDL consists of five categories (12 items each plus an optional comment item): Awareness, Learning Strategies, Learning Activities, Evaluation, and Interpersonal Skills. Items are rated on a 5-point Likert scale (5 = Always to 1 = Never). Each category includes an "Any other" response space to capture additional student inputs not addressed by fixed items, as shown in Table 3.

Table 3. SRSSDL Category Definitions of Self-Directed Learner Attributes
SRSSDL Category Definitions of Self-directed Learner Attributes

Attributes	Score Range	Category Definitions
Awareness	1-60	Learner's understanding of factors that contribute to becoming a self-directed learner.
Learning Strategies	1-60	Various strategies self-directed learners should adopt in order to become self-directed in their own learning processes.
Learning Activities	1-60	Requisite learning activities learners should actively engage in order to become self-directed in their learning processes.
Evaluation	1-60	Learner specific attributes in order to help monitor their learning activities.
Interpersonal Skills	1-60	Learner skills focused on interpersonal relationships, which are pre-requisite to becoming self-directed learners.

AI/ChatGPT Use and Engagement Survey

To characterize AI-supported learning behaviors, students completed a short AI/ChatGPT Use and Engagement questionnaire. This measured: frequency of ChatGPT use for mathematics, common purposes like explanations, solution checking, step-by-step guidance, practice generation), reliance patterns, and verification behaviors like checking answers with notes/teacher/resources). Items were rated on a Likert scale with optional open-ended responses.

Mathematics Performance Measure

Mathematics performance was measured using standardized mathematics scores retrieved from school records (school-based mathematics assessments). Scores were accessed through a data-sharing agreement and linked to survey responses using anonymized codes. This approach ensured performance data reflected authentic school assessment outcomes during the study period.

Focus Group Discussion Guide

A semi-structured FGD guide was used to explore how learners use ChatGPT in mathematics study, including prompting habits, help-seeking decisions, verification practices, perceived learning gains (conceptual understanding vs task completion), and challenges such as confusion, misinformation, or dependence. FGDs were audio-recorded with participant permission.

Data Collection Procedures

After securing permissions from school authorities and obtaining ethical clearance, data collection was implemented in several coordinated steps. Students from selected intact sections were first screened in class using a brief item to determine prior or current use of AI tools (e.g., ChatGPT) for mathematics learning, and those who met the eligibility criteria were invited to participate. The researchers then explained the purpose of the study, confidentiality safeguards, voluntary participation, and the right to withdraw at any time without penalty, after which parental/guardian consent and student assent were obtained. Quantitative data were gathered through the administration of the SRSSDL and the AI/ChatGPT engagement questionnaire during school hours in classrooms

or designated research areas. To measure mathematics performance, standardized mathematics scores were retrieved from official school records under a data-sharing agreement and were linked to survey responses using anonymized participant codes to ensure that no identifying information appeared in the dataset. For the qualitative strand, students who volunteered were scheduled for focus group discussions (FGDs) conducted on campus in groups of 6–10 participants; these sessions were held in a quiet venue, audio-recorded with permission, and facilitated in a manner that minimized disruption to regular classes. Throughout the process, all survey data, linked scores, and audio files were managed securely, with identifiers removed and access restricted to the research team to protect participants' privacy.

Data Analysis

Quantitative Analysis

Quantitative data were analyzed using appropriate statistical software. The analysis began with descriptive statistics, including means, standard deviations, frequencies, and percentages, to summarize SRSSDL readiness levels, patterns of ChatGPT use and engagement, and students' mathematics performance scores. To establish the internal consistency of the instruments, reliability testing was conducted (e.g., Cronbach's alpha) for both the SRSSDL and the AI/ChatGPT engagement questionnaire. Relationships among self-directed learning readiness, ChatGPT engagement, and mathematics performance were then examined using correlation analysis, applying Pearson's r when assumptions of normality were met and Spearman's rho when normality was violated. Finally, multiple regression analysis was performed to determine whether SDL readiness and ChatGPT engagement significantly predicted mathematics performance, with additional control variables such as grade level, sex, or access-related indicators included when available and appropriate.

Qualitative Analysis

Audio recordings were transcribed verbatim. Data were analyzed using thematic analysis, involving familiarization, initial coding, theme development, theme review, and refinement. Trustworthiness was enhanced through strategies such as code review/peer debriefing, maintaining an audit trail, and participant validation of key points when feasible.

Mixed-Methods Integration

Results were integrated using triangulation and a joint display approach. Quantitative findings (e.g., whether ChatGPT engagement is associated with performance and SDL level) were compared with qualitative themes (e.g., how students use ChatGPT: explanation-seeking vs answer-copying; verification behaviors; overreliance). Convergent, complementary, or divergent patterns were identified to strengthen interpretation.

Ethical Considerations

The study complied with the Data Privacy Act of 2012 (RA 10173). Participants were informed about the purpose of the study, voluntary participation, confidentiality, and the right to withdraw at any time without penalty. Survey responses were anonymized, and mathematics scores were linked using codes rather than names. Data were stored securely and accessed only by the research team.

Results and Discussion

Self-Directed Learning (SDL) Levels of Generation Z Students

To evaluate students' levels of self-directed learning (SDL), the study administered the Self-Rating Scale of Self-Directed Learning (SRSSDL; Williamson, 2007) to 272 junior high school students. SRSSDL scores were categorized into Low (60–140), Moderate (141–220), and High (221–300). Results showed that the majority of students (130; 47.79%) were at the moderate SDL level, indicating developing capacity to plan, implement, and evaluate their learning. Meanwhile, 80 students (29.41%) demonstrated high SDL, and 62 students (22.79%) fell within the low SDL category.
From a theoretical standpoint, this distribution is consistent with Knowles' SDL perspective, which treats SDL as a developmental capability rather than a fixed attribute. The predominance of moderate SDL suggests that many learners are in a transitional stage—capable of some independent learning behaviors but still needing structured support for goal-setting, monitoring, and evaluation. In mathematics, where learning requires persistence and metacognitive monitoring, students in the low SDL group may be at greater risk for disengagement and reliance

on external assistance. This underscores the importance of explicitly teaching SDL-related skills like planning routines, reflection prompts, self-checking strategies) as part of mathematics instruction.
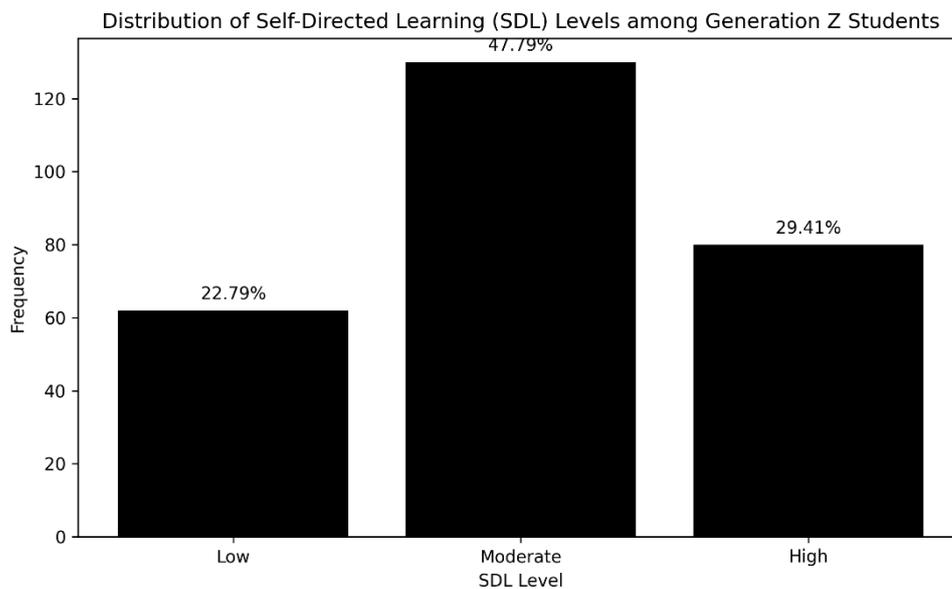
Figure 1. Distribution of Self-Directed Learning (SDL) Levels among Generation Z Students based on SRSSDL scores (N = 272).

Descriptive Statistics of Key Variables

Table 4. Descriptive Statistics of Key Variables

Variable	Mean	Standard Deviation	Minimum	Maximum
SRSSDL Score	187.89	52.10	82	295
ChatGPT Usage Score	3.89	0.98	1	5
Mathematics Performance	85.58	7.28	75	96

Note: ChatGPT usage score is based on a 5-point Likert scale (1 = Never, 5 = Always). Mathematics performance is based on standardized test scores.

Table 4 presents descriptive statistics for SRSSDL, ChatGPT usage, and mathematics performance. The average SRSSDL score (M = 187.89, SD = 52.10) indicates moderate SDL readiness overall, reinforcing the categorical distribution. ChatGPT usage (5-point scale: 1 = Never to 5 = Always) yielded a mean of M = 3.89 (SD = 0.98), suggesting that students frequently used ChatGPT to support mathematics learning. Mathematics performance was relatively high (M = 85.58, SD = 7.28, range 75–96) based on standardized assessments. The variability in SRSSDL, ChatGPT usage, and performance suggests sufficient dispersion to examine relationships among these variables.

Interpreting these patterns through Cognitive Load Theory (CLT) provides an explanatory lens: mathematics tasks often impose high intrinsic cognitive load, and AI tools may reduce barriers by providing immediate explanations or structured steps. However, CLT also cautions that supports can become counterproductive if they reduce productive struggle or shift attention to superficial cues rather than essential reasoning. Thus, frequent ChatGPT use may reflect perceived utility, but its learning value depends on whether it supports schema-building (germane load) rather than simply reducing effort.

Reliability of Instruments

Table 5. Reliability coefficients (Cronbach's alpha)

Instrument	Subscale	Cronbach's α
SRSSDL	Overall	.95
	Awareness	.88
	Learning Strategies	.91
	Learning Activities	.89

	Evaluation	.90
	Interpersonal Skills	.87
AI/ChatGPT Engagement	Overall	.86

Correlation Analysis

Pearson correlation analysis examined relationships among SDL readiness (SRSSDL), ChatGPT usage, and mathematics performance (Table 5). Results showed a very strong positive correlation between SRSSDL scores and mathematics performance (r = .849, p < .001). This indicates that students with higher SDL readiness tended to achieve substantially higher mathematics scores. The strength of this association suggests that SDL-related competencies—such as strategic learning behaviors and evaluative monitoring—are highly aligned with successful performance in mathematics.

Table 6. Pearson Correlation Coefficients Among Key Variables (N = 272)

Variable	**1**	**2**	**3**
1.SRSSDL Score	—		
2. ChatGPT Usage Score	.080	—	
3. Math Performance Score	.849**	.227**	—

Note. ChatGPT usage score is based on a 5-point Likert scale (1 = Never, 5 = Always). ** p < .01 (2-tailed)

ChatGPT usage showed a weak but statistically significant positive correlation with mathematics performance (r = .227, p < .001). This indicates that higher ChatGPT usage is associated with slightly higher performance, but the effect is modest. A theoretically grounded interpretation is that ChatGPT may function as a supplemental learning aid—offering feedback, explanations, and examples that can help students proceed when encountering difficulties, especially during independent study.

In contrast, the relationship between SRSSDL and ChatGPT usage was very weak and not statistically significant (r = .080, p = .187). This suggests that students' SDL readiness does not meaningfully predict how frequently they use ChatGPT; students across low to high SDL levels may use the tool. This is an important quantitative insight because it implies that use is widespread, but it does not indicate whether the tool is being used strategically or passively—an issue that is crucial when interpreting the modest correlation between ChatGPT use and performance.

Critical Evaluation

Although ChatGPT usage is positively related to mathematics performance, the small effect size suggests that frequency of use alone is not a strong driver of achievement. Several theoretical risks help explain why this relationship may be weak and why potential negative effects must still be considered even when correlations are positive. From the perspective of cognitive offloading, students may outsource key steps or reasoning to AI, reducing deep processing and weakening long-term retention, which can limit performance gains. Relatedly, automation bias or overtrust may occur when learners accept AI outputs as correct without verification; in mathematics, this can reinforce misconceptions and lead to errors during assessments. In addition, frequent AI use may reflect help-seeking pathologies, where support-seeking becomes maladaptive—such as asking for solutions too early or relying on the tool instead of persisting through problem-solving—thereby reducing effort and practice opportunities. Finally, the illusion of understanding may arise when students feel they have learned after reading AI-generated explanations but struggle to apply the reasoning independently during tests. Taken together, these risks do not contradict the positive correlation; instead, they imply that the educational value of ChatGPT likely depends on the quality of engagement which including verification, reflection, and attempt-first behavior—which cannot be fully captured by frequency measures alone.

Long-term considerations of AI use

Given the weak association between ChatGPT usage and mathematics performance (r = .227) and its smaller unique contribution in regression (β = .159) compared with SDL (β = .836), increased frequency of AI use alone may not produce proportionate learning gains. Consequently, the long-term normalization of ChatGPT in mathematics warrants attention to risks of overuse, dependency, and academic integrity. Habitual reliance may reduce persistence and metacognitive monitoring, encouraging convenience over productive struggle, while uncritical use can blur the line between legitimate support (explanations, hints) and misconduct (copying complete solutions), potentially compromising assessment validity and masking misconceptions. These concerns highlight

the need for sustained AI literacy, verification habits, self-regulation, and clear school policies defining acceptable use and requiring evidence of reasoning.

Regression Analysis

Multiple linear regression was conducted to determine whether SDL readiness and ChatGPT usage predict mathematics performance. The model explained 74.6% of the variance in mathematics performance (R^2 = .746; Adjusted R^2 = .744) and was statistically significant, $F(2, 269)$ = 395.180, $p < .001$, indicating strong predictive power when both predictors are considered simultaneously. Both predictors were significant: SRSSDL score (β = .836, $p < .001$) and ChatGPT usage (β = .159, $p < .001$). This suggests that higher SDL readiness is the primary predictor of mathematics performance, while ChatGPT usage contributes a smaller but statistically significant incremental effect.

Theoretically, this pattern aligns with SDL and self-regulation perspectives: students who can manage their learning (planning, strategy use, monitoring, evaluation) are more likely to succeed in mathematics, regardless of tool availability. The smaller positive coefficient for ChatGPT usage suggests that AI tools may provide supplementary support, but they do not substitute for SDL competencies. Importantly, given the potential risks of cognitive offloading and automation bias, these findings support a cautious interpretation: ChatGPT may enhance performance when used as a scaffold that complements SDL (e.g., prompting explanation, checking reasoning), but it could become counterproductive if it reduces independent reasoning and evaluation—especially for students in the low SDL group.

Table 7. Model Summary of the Regression Analysis on Mathematics Performance

Model	R	R Square	Adjusted R Square
1	0.864	0.746	0.744

Table 8. ANOVA Table for the Regression Model Predicting Mathematics Performance

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	10769.102	2	5384.551	395.180	< .001
Residual	3665.277	269	13.626		
Total	14434.379	271			

Table 9. Regression Coefficients for Predicting Mathematics Performance

Predictor	B	Std. Error	Beta	t	Sig.
(Constant)	58.984	1.179	–	50.04	< .001
SRSSDL Score	0.117	0.004	0.836	27.129	< .001
ChatGPT Usage	1.188	0.23	0.159	5.171	< .001

Overall Quantitative Interpretation

Overall, the quantitative findings indicate that self-directed learning readiness is strongly associated with and predictive of mathematics performance, while ChatGPT usage shows a weaker but significant positive relationship with performance. These results imply that AI tools may add value, but the dominant factor remains learners' SDL capacity. To maximize benefits and minimize harms suggested by theory, schools may need to pair AI access with explicit instruction in verification habits, reflective use, and metacognitive monitoring so that AI functions as a facilitator of learning rather than a shortcut.

Qualitative Results and Discussion

Coding Process and Trustworthiness

Focus group discussion transcripts were analyzed using thematic analysis. The researchers began with familiarization by reading transcripts repeatedly to understand the overall meanings in students' accounts. Responses were segmented into meaning units and assigned initial open codes capturing patterns of ChatGPT use

in mathematics learning example explanation-seeking, step-by-step guidance, prompt refinement, verification, and shortcut behaviors). Through constant comparison across participants and groups, codes were refined (merged, split, and clarified), organized into categories, and clustered into subthemes. Subthemes were subsequently consolidated into overarching themes that represented consistent patterns across the dataset. A coding trail (Table 9) illustrates how representative excerpts progressed from raw statements to codes, subthemes, and final themes.

Table 10. Coding trail

Excerpt (condensed)	Initial code	Subtheme	Theme
"I ask ChatGPT when I'm stuck; it gives steps."	Step-by-step support	Accessibility & convenience	Personalized support and motivation
"I try first then check; I'm not scared to be wrong."	Confidence to attempt	Confidence & independence	Personalized support and motivation
"Sometimes I just copy the solution."	Shortcut behavior	Passive learning tendencies	Challenges in critical thinking & overreliance
"It became easy so I stopped solving before asking."	Reduced persistence	Reduced effort/persistence	Challenges in critical thinking & overreliance
"I ask again in a different way until it makes sense."	Prompt refinement	Iterative questioning	ChatGPT as a learning companion
"It doesn't judge me; I can ask many times."	Judgment-free support	Emotional comfort	ChatGPT as a learning companion

Trustworthiness and Triangulation

Credibility was strengthened through methodological triangulation by linking the qualitative themes to the study's quantitative measures (SRSSDL dimensions, ChatGPT engagement indicators, and standardized mathematics performance). Rather than treating the qualitative findings as separate, the researchers used them to clarify *how* students' reported ChatGPT practices relate conceptually to SDL processes (planning, strategy use, monitoring, evaluation) and to plausible performance outcomes. Dependability was supported by maintaining an audit trail documenting coding decisions, codebook revisions, and theme refinements. Confirmability was strengthened through reflexive memoing and peer debriefing to check theme coherence and reduce researcher bias. Transferability was addressed through contextual description and representative quotations for each subtheme, enabling readers to judge applicability to similar junior high school contexts.

Thematic analysis yielded three major themes, each with two subthemes, reflecting Generation Z students' experiences of using ChatGPT in support of their self-directed learning in mathematics. These themes offer insight into both the benefits and challenges of AI-enhanced learning.

Theme 1: Personalized Support and Motivation
This theme highlights the role of ChatGPT as a supportive and accessible learning tool that enhances students' motivation and encourages independent learning. Many students shared that ChatGPT helped them clarify difficult mathematical concepts, which in turn gave them the confidence to approach problem-solving tasks independently.

Subtheme 1.1: Accessibility and Convenience
Students frequently highlighted the 24/7 availability of ChatGPT as one of its most valuable features. The ability to receive immediate assistance—especially outside of class hours—allowed them to address learning challenges as they arose, without having to wait for a teacher's input. This real-time support was seen as empowering and helped maintain learning momentum.
This was reflected in statements such as:
"When I'm reviewing at 10 p.m. and get stuck, I ask ChatGPT right away" (P4).
"I used to wait until the next day to ask the teacher. Now, I can study right after class" (P7).

Subtheme 1.2: Boost in Confidence and Independence
The tool also played a role in boosting students' confidence to tackle challenging tasks on their own. Several participants shared that ChatGPT encouraged them to attempt problem-solving independently before turning to others for help, fostering a greater sense of self-reliance in their learning.
This perspective was captured in remarks such as:
"I don't feel scared of being wrong because I can check with ChatGPT—so I try on my own first" (P9).
"It's like having a tutor who won't get tired of my questions" (P2).

Theme 2: Challenges in Critical Thinking and Overreliance
While ChatGPT provided valuable support, some students also acknowledged its potential limitations. Several participants reflected on their tendency to rely too heavily on the tool, noting that this dependence occasionally hindered the development of deeper thinking and problem-solving skills.

Subtheme 2.1: Passive Learning Tendencies
Several participants admitted that they sometimes copied ChatGPT's responses without fully grasping the underlying concepts. This passive use of the tool limited opportunities for critical thinking and hindered the development of essential problem-solving skills.
This concern was evident in comments like:
"There are times I just copy the solution and move on" (P5).
"Even if I don't understand, I still use the answer to pass the task" (P11).

Subtheme 2.2: Reduced Problem-Solving Persistence
Students also noted that the convenience of accessing ready-made solutions sometimes discouraged them from putting in the effort to solve problems on their own, reducing opportunities for independent reasoning.
This sentiment was echoed in responses such as:
"It makes things too easy. I stopped working a problem out on paper before asking" (P1).
"I used to think first. Now I just ask ChatGPT" (P10).

Theme 3: ChatGPT as a Learning Companion
Students described ChatGPT not just as an information source, but as a conversational partner in their learning journey. Its interactive and nonjudgmental nature created a supportive space where they felt comfortable asking questions—often repeatedly—and exploring ideas without fear of being wrong. This environment encouraged reflection and allowed students to better assess and deepen their understanding over time.

Subtheme 3.1: Dialogic Exploration of Concepts
The ability to rephrase questions and receive tailored, adaptive explanations allowed students to refine their understanding, supporting both conceptual clarity and the development of metacognitive skills.
This was illustrated by remarks such as:
"If I don't get the answer, I ask again in a different way until it makes sense" (P6).
"Sometimes I ask, then try to explain the problem back. That helps me see what I missed" (P8).

Subtheme 3.2: Emotional Comfort and Stress Relief
Many students noted that ChatGPT provided a judgment-free space for asking questions, which reduced anxiety and increased their willingness to engage with difficult topics.
Examples include:
"It doesn't judge me. I can ask ten times and it never sighs" (P3).
"In class, I get shy. With ChatGPT, I ask freely" (P12).

The qualitative themes align closely with the study's quantitative findings. The strong positive correlation between SDL levels and mathematics performance may be attributed to the motivational and confidence-building effects described in Theme 1. These findings support Knowles' theory of self-directed learning, as students demonstrated autonomy and initiative in managing their learning with AI assistance.

However, Theme 2 provides a deeper explanation for the relatively weak correlation between ChatGPT usage and academic performance. Students who used ChatGPT passively or as a shortcut failed to develop critical thinking

and problem-solving skills—underscoring the importance of self-regulation as a moderating factor. This aligns with the study's conceptual framework and with constructivist learning theory, which emphasizes cognitive engagement and meaning-making.

Theme 3 reflects ChatGPT's role in fostering metacognitive reflection and reducing learning-related anxiety. Its dialogic nature allowed students to revisit problems, clarify understanding, and build confidence without the fear of negative judgment. These insights are consistent with the AI in Education Framework (Luckin et al., 2016), which positions AI as a personalized, adaptive learning partner.

Taken together, the qualitative findings illustrate that ChatGPT can support self-directed learning and enhance mathematics engagement—provided it is used critically and with intention. Strengthening students' AI literacy and self-regulation is therefore essential to ensure that such tools contribute meaningfully to learning.

Mixed-Methods Integration

Triangulation indicated that the relationship between ChatGPT use, self-directed learning, and mathematics performance is best understood as conditional on how ChatGPT is used. Students' accounts showed that ChatGPT can support AI-facilitated SDL when it is used as a scaffold for explanation-seeking, guided practice, and iterative questioning—behaviors aligned with SDL dimensions such as learning strategies and evaluation. However, narratives also revealed risks that can weaken SDL, including shortcut behaviors, reduced persistence, and limited verification, which may restrict conceptual understanding and undermine performance. Taken together, the integrated evidence suggests that ChatGPT engagement alone is not sufficient; rather, the *quality of engagement* (verification, reflection, strategy-driven use) appears central in determining whether AI-supported SDL contributes to meaningful mathematics learning outcomes.

Summary

This mixed-methods study examined the relationship between AI-facilitated self-directed learning (SDL) and mathematics performance among Generation Z junior high school students, focusing on ChatGPT use. Quantitatively, 272 learners completed the SRSSDL and a ChatGPT usage survey, and their responses were linked to standardized mathematics scores. Results showed that most students demonstrated moderate SDL readiness, with a substantial group at high SDL and a notable portion at low SDL. Descriptive statistics indicated moderate SDL overall, frequent ChatGPT use, and generally high mathematics performance. Correlational analysis revealed a very strong positive relationship between SDL and mathematics performance, a weak but significant positive relationship between ChatGPT use and mathematics performance, and a non-significant relationship between SDL and ChatGPT frequency of use. Regression analysis further showed that SDL and ChatGPT use jointly predicted mathematics performance, with SDL emerging as the strongest predictor. Qualitatively, thematic analysis of FGDs generated three themes: (1) ChatGPT as a source of personalized support and motivation, (2) challenges related to critical thinking and overreliance, and (3) ChatGPT as a learning companion that supports dialogic exploration and emotional comfort. Mixed-methods integration indicated that the benefits of ChatGPT are conditional on quality of use, particularly strategic engagement, verification behaviors, and self-regulation.

Conclusion

The findings indicate that self-directed learning readiness is a major determinant of mathematics performance among Generation Z students. Students who demonstrate stronger SDL capacities—especially in planning, learning strategies, monitoring, and evaluation—tend to achieve higher mathematics scores. While ChatGPT use shows a positive contribution to mathematics performance, its effect is smaller, suggesting that AI tools function best as supplementary supports rather than substitutes for core learning competencies. Importantly, the study also highlights potential risks: frequent AI use may encourage cognitive offloading, overtrust in AI outputs, and reduced persistence when learners rely on quick solutions instead of engaging in deeper reasoning. The qualitative findings reinforce that ChatGPT can enhance motivation, confidence, and access to help, but it can also undermine critical thinking when used passively. Overall, the study concludes that ChatGPT can support mathematics learning when integrated with strong SDL behaviors and responsible use practices; however, meaningful learning gains depend largely on students' self-regulation, metacognitive monitoring, and intentional engagement with AI-generated feedback.

Recommendations

For mathematics teachers, it is recommended to explicitly teach AI-supported learning routines by establishing classroom norms such as requiring students to attempt problems first before consulting AI, explaining solutions in their own words, and verifying AI-generated answers using notes, teacher-provided examples, or alternative solution methods. Teachers should also strengthen students' self-directed learning skills through structured scaffolds such as goal-setting templates, weekly learning plans, reflection logs, and self-check checklists aligned with key SRSSDL dimensions like awareness, learning strategies, and evaluation. In addition, classroom assessments and learning tasks should be designed to emphasize reasoning rather than copying by incorporating open-ended problems, error analysis activities, and solution-justification tasks that discourage simply pasting AI outputs. Finally, verification and evaluation should be taught as core mathematical habits by training students to check AI solutions for accuracy in units, logical steps, computations, and final answers, and to identify common reasoning errors that may occur in AI-generated explanations.

For school leaders and program coordinators, developing school-based AI literacy guidelines is essential to promote responsible AI use, protect academic integrity, and ensure compliance with the Data Privacy Act of 2012 (RA 10173). Schools should also provide teacher capacity-building opportunities through training on AI-integrated lesson design, formative assessment strategies, and practical methods for guiding learners to use AI as a scaffold rather than a shortcut. Moreover, schools are encouraged to establish monitoring and support systems that allow teachers to track AI-related learning behaviors and provide targeted interventions, especially for students with low SDL readiness who may be more vulnerable to overreliance or passive use of AI tools.

For students, ChatGPT should be used as a learning tutor rather than a solver by prioritizing requests for explanations, examples, and hints instead of complete final answers. Learners are encouraged to practice a "verify and reflect" habit by checking AI responses using notes or alternate methods and writing brief reflections on what they learned and how their understanding improved. To build independence gradually, students should reduce reliance over time by practicing similar problems without AI support after receiving initial guidance, ensuring that learning becomes internalized rather than tool-dependent.

For future researchers, it is recommended to measure the quality of AI use rather than focusing only on frequency by including indicators such as verification behaviors, prompting strategies, and critical evaluation of AI outputs. Researchers may also test more explanatory models by examining mediators and moderators for example, whether SDL mediates the relationship between ChatGPT use and performance, or whether self-regulation moderates the benefits and risks of AI use. Longitudinal or experimental designs are encouraged to track changes over time and strengthen causal interpretation, and further studies should compare groups and contexts across grade levels, achievement levels, and access conditions like internet or device availability to explore equity implications and identify which learners benefit most from AI-supported learning.

References

Ali, M. S. B., Yasmeen, R., & Munawar, Z. (2023). The Impact of Technology Integration on Student Engagement and Achievement in Mathematics Education: A Systematic Review. *International journal of computer integrated manufacturing, 6*(3), 222-232.

Anderson, M., & Anderson, M. (2024, April 14). Teens, Social Media and Technology 2018. Pew Research Center. https://www.pewresearch.org/internet/2018/05/31/teens-social-media-technology-2018

Anderson, M., & Jiang, J. (2018). Teens, social media & technology 2018. *Pew research center*, 31(2018), 1673-1689.

Banitt, J., Theis, S., & Van Leeuwe, L. (2013). The effects of technology integration on student engagement.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative research in psychology, 3*(2), 77-101.

Byeon, S., & Kim, N. (2020). Impact of Korean students' individual learning time on math performance: differential effect of teachers' assessment competency. *Asia Pacific Education Review, 21*(4), 601-613.

Cadorin, L., Bortoluzzi, G., & Palese, A. (2013). The Self-Rating Scale of Self-Directed Learning (SRSSDL): A factor analysis of the Italian version. *Nurse Education Today, 33*(12), 1511–1516. https://doi.org/10.1016/j.nedt.2013.04.010

Cadorin, L., Suter, N., Saiani, L., Naskar Williamson, S., & Palese, A. (2011). Self-Rating Scale of Self-Directed Learning (SRSSDL): preliminary results from the Italian validation process. *Journal of Research in Nursing, 16*(4), 363-373.

Darmayanti, R. (2024). Programmed learning in mathematics education before and after the pandemic: Academics Integrate technology. *Assyfa Learning Journal, 2*(1), 40-56.

Foster, N., & Schleicher, A. (2022). Assessing creative skills. *Creative Education, 13*(1), 1-29.

Gabrielova, K., & Buchko, A. A. (2021). Here comes Generation Z: Millennials as managers. *Business Horizons, 64*(4), 489-499.

Geiger, A. (2025, April 24). Defining generations: Where Millennials end and Generation Z begins. Pew Research Center. https://www.pewresearch.org/short-reads/2019/01/17/where-millennials-end-and-generation-z-begins/

Guidance for generative AI in education and research. (2026, January 16). UNESCO. https://www.unesco.org/en/articles/guidance-generative-ai-education-and-research

Harry, A. (2023). Role of AI in Education. *Interdiciplinary Journal and Hummanity (INJURITY), 2*(3), 260-268.

How, A., & Hung, I. (2019). A reflection on the use of artificial intelligence tools for the meaningful learning of mathematics. *Pythagoras, 40*(1), Article 831. https://doi.org/10.xxxx/pythagoras.v40i1.831

Knowles, M. S. (1975). *Self-directed learning*. New York, NY: Associated Press.

Lee, C. S., Osop, H., Kelni, G., & Goh, D. H. L. (2015). Investigating the use of YouTube as a self-directed learning platform. RB Allen et al, 308-310.

Luckin, R., Holmes, W., Griffiths, M., & Forcier, L. B. (2016). *Intelligence unleashed: An argument for AI in education*. Pearson.

Maskar, S., Herman, T., Dasari, D., & Puspaningtyas, N. D. (2023). Creativity in Mathematics: Mathematical Reasoning Ability of Indonesian Students and Solution Recommendation. *Acta Scientiae, 25*(5), 303-331. https://doi.org/10.17648/acta.scientiae.7813

Munaye, Y. Y., Admass, W., Belayneh, Y., Molla, A., & Asmare, M. (2025). ChatGPT in Education: A Systematic Review on opportunities, challenges, and future directions. *Algorithms, 18*(6), 352. https://doi.org/10.3390/a18060352

Ní Shé, C., Ní Fhloinn, E., & Mac an Bhaird, C. (2023). Student engagement with technology-enhanced resources in mathematics in higher education: A review. *Mathematics, 11*(3), 787.

OECD (2023), PISA 2022 Results (Volume I): The State of Learning and Equity in Education, PISA, OECD Publishing, Paris, https://doi.org/10.1787/53f23881-en.

OECD. (2019). PISA 2018 Results (Volume I): *What students know and can do*. Paris: OECD Publishing.

Orbeta, A. C., & Paqueo, V. B. (2022). Philippine education: Situationer, challenges, and ways forward (No. 2022-23). PIDS Discussion Paper Series.

Ornedo, J. M. (2020, December 10). Philippines lowest out of 58 countries in 4th-grade math, science —int'l study. GMA News Online. https://www.gmanetwork.com/news/topstories/nation/767542/philippines-lowest-out-of-58-countries-in-4th-grade-math-science-int-l-study/story

Parasuraman, R., & Riley, V. (1997). Humans and automation: Use, misuse, disuse, abuse. *Human factors*, *39*(2), 230-253. https://doi.org/10.1518/001872097778543886

Piaget, J. (1950). The psychology of intelligence (M. Piercy & D. E. Berlyne, Trans.). Routledge & Kegan Paul.

PISA 2022 Results (Volume I). (2023, December). https://www.oecd.org/. Retrieved February 22, 2026, from https://www.oecd.org/en/publications/pisa-2022-results-volume-i_53f23881-en/full-report.html?

Pousson, J., & Myers, K. (2018). Ignatian Pedagogy as a Frame for Universal Design in College: Meeting Learning Needs of Generation Z. *Education Sciences, 8*(4), 193. https://doi.org/10.3390/educsci8040193

Puppart, B., & Aru, J. (2025). Short-term AI literacy intervention does not reduce over-reliance on incorrect ChatGPT recommendations. arXiv (Cornell University). https://doi.org/10.48550/arxiv.2503.10556

Shatto, B., & Erwin, K. (2016). Moving on from millennials: Preparing for generation Z. *The Journal of Continuing Education in Nursing, 47*(6), 253-254.

Singh, E., Vasishta, P., & Singla, A. (2024). AI-enhanced education: exploring the impact of AI literacy on generation Z's academic performance in Northern India. Quality Assurance in Education.

Trocado, A., dos Santos, J. M., Saimon, M., & Lavicza, Z. (2026). Learning Quadratic Functions with ChatGPT: An Innovative Experience in High School Mathematics Education. *International Journal of Education in Mathematics, Science and Technology*, *14*(1), 296-314.https://doi.org/10.46328/ijemst.5074

Vygotsky, L. S. (1978). Mind in society: The development of higher psychological processes (M. Cole, V. John-Steiner, S. Scribner, & E. Souberman, Eds. & Trans.). Harvard University Press.

Williamson, S. N. (2007). Development of a self-rating scale of self-directed learning. *Nurse Researcher, 14*(2), 66–83. http://doi.org/10.7748/nr2007.01.14.2.66.c6022

Yoo, J. (2024). Self-directed Learning Ability and Shadow Education Expenditures: A Comparison of Impact on Student Achievement in Korea During COVID-19. *SAGE Open, 14*(2), 21582440241245206.

Zreik, M. (2024). Redefining mathematics education in the age of artificial intelligence: Challenges and opportunities. *Impacts of globalization and innovation in mathematics education*, 19-40.

Entrepreneurship Education, Curriculum Transformation, and Artificial Intelligence: A Bibliometric Analysis from the Global South

Nomfundo Gladys Khoza[1] | ⬤ / khozan@cut.ac.za
Central University of Technology, Faculty of Management Sciences, Business and Support Studies,
Bloemfontein, South Africa

Abstract
This study examines the intersection of Artificial Intelligence (AI), entrepreneurship education, and curriculum transformation in the Global South. Using a systematic bibliometric analysis of 253 publications from 2019–2024 indexed in Scopus, Web of Science, and JSTOR, the study maps publication trends, intellectual structures, and collaborative networks shaping this emerging field. The analysis identifies four key themes: AI-enabled pedagogical innovation, digitalisation and curriculum redesign, entrepreneurship education in developing contexts, and global research collaboration. Guided by Activity Theory, the study conceptualises AI as a mediating artefact shaping interactions between pedagogy, technology, and institutional contexts. The findings highlight the transformative potential of AI in advancing entrepreneurship education while revealing persistent challenges related to infrastructure, policy, and digital inequality. The study contributes theoretical and policy insights for fostering inclusive, contextually responsive, and innovation-driven curriculum transformation in Global South higher education.

Keywords: Entrepreneurship education, Curriculum transformation, Artificial intelligence, Digital transformation, Innovation in higher education

---

[1] Corresponding Author

Introduction

The global economy has undergone profound transformation driven by technological advancements, digitalisation, and artificial intelligence (AI), reshaping how knowledge is produced, shared, and applied within higher education. As universities navigate this digital age, entrepreneurship education has become a central mechanism for fostering innovation, resilience, and employability among graduates (Fayolle et al., 2020). Entrepreneurship education is no longer confined to business schools but has evolved into an interdisciplinary field that prepares learners to think creatively, identify opportunities, and generate sustainable solutions to complex socio-economic challenges (Neck et al., 2021). In the Global South, this imperative is even more pronounced, as educational institutions seek to balance access, quality, and relevance in the face of rapid technological change and persistent developmental inequalities (Aparicio et al., 2021).

Despite the growing recognition of the role of entrepreneurship education in addressing socio-economic development, a persistent problem lies in the slow transformation of curricula to reflect the digital realities of the twenty-first century. Many universities in developing contexts continue to deliver entrepreneurship education using outdated pedagogical models that fail to integrate AI and digital competencies (Khoza, 2022; Ratten et al., 2021). Consequently, there is a widening gap between the entrepreneurial skills cultivated in higher education and those demanded by digitally driven economies (Maritz et al., 2022). This disjunction undermines the transformative potential of entrepreneurship education as a tool for inclusive growth, particularly in the Global South where digital adoption and innovation ecosystems are unevenly developed (Nambisan et al., 2019). The first major contribution of this study is its focus on the intersection of entrepreneurship education, curriculum transformation, and AI from a Global South perspective. Existing research on AI in entrepreneurship education is heavily concentrated in the Global North, overlooking context-specific constraints such as limited digital infrastructure, socio-economic disparities, and institutional inertia (Nambisan et al., 2020). By employing bibliometric analysis, this study identifies emerging research trends, key contributors, and thematic clusters, thereby offering a holistic understanding of how AI is shaping entrepreneurship education within developing contexts.

Secondly, this paper contributes to the theoretical discourse on curriculum transformation by examining how AI-driven pedagogical innovations are influencing entrepreneurship education frameworks. Scholars have argued that AI offers opportunities to personalise learning, enhance experiential teaching, and foster digital entrepreneurship mindsets (García-Morales et al., 2021). However, empirical evidence on how these technologies are integrated into entrepreneurship curricula remains limited. Through systematic mapping, this research provides evidence-based insights into the evolution of curriculum design and pedagogical strategies informed by AI in higher education. Thirdly, this study advances policy and practice by highlighting the implications of digital transformation for educators, curriculum designers, and policymakers in the Global South. As AI technologies increasingly mediate learning environments, there is a pressing need to rethink teaching methodologies and assessment frameworks that cultivate entrepreneurial thinking and digital fluency (Maritz et al., 2023). This bibliometric investigation therefore serves as a foundation for future empirical studies and policy interventions aimed at aligning entrepreneurship education with the demands of digital economies.

In summary, this paper addresses the underexplored nexus between entrepreneurship education, curriculum transformation, and artificial intelligence. By adopting a bibliometric lens, it elucidates global research trajectories while situating them within the contextual realities of the Global South. The findings aim to contribute to the reimagining of entrepreneurship education as a dynamic, technology-enabled field capable of driving innovation, inclusion, and sustainable development in emerging economies. This study is guided by the following research questions:

RQ1: What are the publication trends in research on artificial intelligence, entrepreneurship education, and curriculum transformation between 2019 and 2024?
RQ2: Who are the most productive authors, institutions, and countries contributing to this research field?
RQ3: Which journals and publications are the most influential based on citation impact?
RQ4: What thematic clusters emerge from keyword co-occurrence analysis in the literature?
RQ5: How is artificial intelligence transforming entrepreneurship education and curriculum design in higher education institutions within the Global South?

Literature review

Artificial Intelligence in Higher Education

The integration of artificial intelligence (AI) in higher education has transformed the landscape of teaching and learning, offering personalised instruction, intelligent tutoring systems, predictive analytics, and automated assessment (Crompton et al., 2023; Zawacki-Richter et al., 2019). Research shows that AI applications can enhance learning efficiency and improve decision-making in academic management (Wang et al., 2024). However, scholars caution that despite its promise, AI in education remains constrained by ethical, technical, and contextual challenges such as algorithmic bias, data privacy, and unequal access to digital infrastructure (García-Morales et al., 2021; Holmes et al., 2021). Recent systematic reviews reveal that most studies on AI in education originate from developed economies, particularly in North America, Europe, and East Asia, where digital ecosystems are more advanced (Chen et al., 2024). This geographical bias leaves a research gap regarding how AI adoption unfolds in developing regions, especially within the Global South (Mhlanga, 2023). The uneven distribution of digital capacity across universities exacerbates educational inequalities, underscoring the need for context-specific studies that explore how AI can support inclusive and transformative learning in resource-constrained environments (Aparicio et al., 2021).

Entrepreneurship Education and Pedagogical Transformation

Entrepreneurship education has evolved from its traditional focus on venture creation to encompass the cultivation of entrepreneurial mindsets, opportunity recognition, and innovation capabilities (Neck et al., 2021; Fayolle et al., 2020). The pedagogical shift towards experiential and problem-based learning underscores the need for dynamic teaching strategies that reflect the realities of contemporary economies (Ratten et al., 2021). Digitalisation has played a key role in this evolution, with online incubators, simulation-based learning, and collaborative virtual platforms reshaping how entrepreneurship is taught (Maritz et al., 2022). Nonetheless, many entrepreneurship curricula remain outdated and misaligned with the digital competencies required in rapidly evolving markets (Nambisan et al., 2019; Maritz et al., 2023). Research indicates that entrepreneurship education in the Global South often faces structural challenges including limited access to technology, insufficient educator training, and rigid institutional frameworks (Brix et al., 2020; Khoza, 2024). These barriers hinder the integration of AI and digital tools that could otherwise enhance creativity, critical thinking, and innovation among students (García-Morales et al., 2021).

Curriculum Transformation and Digitalisation in Higher Education

Curriculum transformation involves rethinking content, pedagogy, and assessment to align with contemporary economic and technological shifts (Fernández et al., 2023). In higher education, digital transformation has become a strategic priority, particularly in the wake of the COVID-19 pandemic, which accelerated the use of online platforms and learning analytics (Díaz-García et al., 2022). Yet scholars highlight that digitalisation is not merely a technological shift but also an institutional and cultural one that requires leadership, resources, and faculty digital literacy (García-Morales et al., 2021; Nambisan et al., 2020). In entrepreneurship education, curriculum transformation is further complicated by the need to embed AI competencies that foster opportunity recognition, data-driven decision-making, and innovative problem-solving (Vecchiarini et al., 2023). The integration of AI into entrepreneurship curricula can enhance student engagement and entrepreneurial intention through personalised learning pathways and simulation environments (Chen et al., 2024). However, adoption remains uneven, with many institutions in the Global South lacking clear frameworks for embedding AI-driven pedagogies within existing curricula (Matsieli et al., 2024).

AI and Entrepreneurship Education in the Global South

The intersection of AI and entrepreneurship education in developing contexts represents an emerging research frontier (Fossen et al., 2024). While evidence from developed economies demonstrates how AI supports creativity, market analysis, and venture simulation, similar studies from the Global South are scarce (Mhlanga, 2023). Scholars attribute this to infrastructural deficiencies, limited policy support, and insufficient institutional readiness for digital transformation (Aparicio et al., 2021). In African and Latin American universities, initiatives linking entrepreneurship and AI remain fragmented and often externally funded, raising questions about sustainability and contextual adaptation (Rambe, 2023). The lack of localised research has resulted in a narrow understanding of how AI can support entrepreneurial learning in diverse socio-economic environments. Addressing this gap is crucial for designing inclusive and transformative curricula that align with the Fourth Industrial Revolution (4IR) and Sustainable Development Goals (SDGs) (Maritz et al., 2023; Nambisan et al., 2020).

Research Gap and Rationale for the Study

The reviewed literature highlights three critical gaps. First, existing research predominantly focuses on AI in general education rather than in entrepreneurship-specific contexts. Second, studies that explore curriculum transformation often adopt conceptual rather than empirical approaches, limiting the evidence base for actionable policy reform. Third, there is limited understanding of how Global South universities are contextualising AI within entrepreneurship education. Consequently, this study employs a bibliometric approach to map global research patterns, identify key contributors, and highlight emerging themes linking AI, entrepreneurship education, and curriculum transformation. By situating these insights within the Global South, the study contributes to the development of inclusive, innovation-driven education systems that prepare graduates for digitally oriented economies.

Theoretical Framework: Activity Theory

Activity Theory (AT), initially developed by Vygotsky (1978) and later expanded by Engeström (1987), provides a robust lens for understanding the dynamic and socially mediated nature of human activity. The theory views learning and development as culturally and contextually embedded processes, mediated through tools, rules, and social interactions. Within educational settings, AT conceptualises activity systems as networks that include a subject (learner or educator), an object (goal or motive of activity), mediating artefacts (technological or conceptual tools), community (institutional and social environment), rules (norms and regulations), and division of labour (roles and responsibilities) (Kaptelinin & Nardi, 2006). These elements interact dynamically to shape how learning, innovation, and transformation occur.
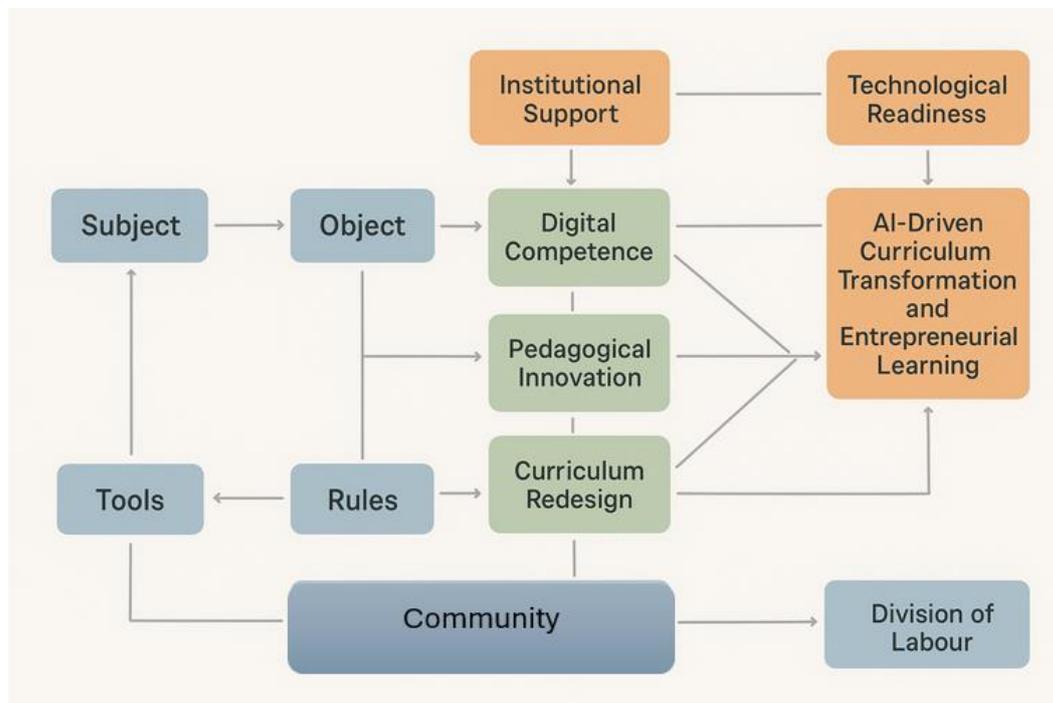
In the context of entrepreneurship education, AT helps to illuminate how educators and students engage with Artificial Intelligence (AI) tools to achieve curriculum transformation and entrepreneurial outcomes (Mwanza-Simwami, 2020). The theory positions AI technologies such as intelligent tutoring systems, data-driven assessments, and generative learning platforms as mediating artefacts that influence both the processes and outcomes of teaching and learning (Mwanza-Simwami, 2020). It also draws attention to the contradictions that emerge within the educational system, such as disparities in access to technology, limited institutional capacity, and varying levels of digital literacy, which often characterise contexts within the Global South (Yamagata-Lynch, 2010). These contradictions are seen not merely as obstacles but as drivers of transformation and innovation within activity systems.

From a bibliometric perspective, Activity Theory offers a conceptual structure for interpreting the knowledge domains, thematic clusters, and co-authorship networks identified in the analysis. Each cluster can be understood as a distinct yet interconnected activity system comprising scholars, research objectives, and methodological tools shaped by socio-cultural and technological contexts. By examining these relationships through the lens of AT, the bibliometric analysis goes beyond descriptive mapping to uncover how research on AI in entrepreneurship education evolves through interactions between subjects (researchers), objects (knowledge production goals), and mediating artefacts (AI, digital pedagogy, and collaborative platforms). This perspective reveals how knowledge is produced, shared, and transformed within the broader educational ecosystem, particularly highlighting the dynamics of curriculum innovation in resource-constrained environments. Overall, adopting Activity Theory allows this study to bridge the macro-level bibliometric insights with micro-level educational practices, offering an integrative understanding of how technological mediation, collaboration, and contextual factors collectively shape entrepreneurship education and curriculum transformation in the Global South.

Conceptual Framework

The framework illustrates the application of Activity Theory in understanding the complex interactions within entrepreneurship education, curriculum transformation, and the integration of Artificial Intelligence (AI) from a Global South perspective. It conceptualises the learning environment as a dynamic system comprising interrelated components including the *subject* (educators and learners), *object* (entrepreneurial competencies and innovation-oriented learning outcomes), and *mediating artefacts* (AI tools, pedagogical strategies, and digital platforms). The *rules* represent institutional policies and ethical norms that guide the incorporation of AI in teaching and learning, while the *community embodies stakeholders* such as higher education institutions, industry partners, and policymakers who contribute to curriculum reform. The *division of labour* captures the distribution of roles, expertise, and responsibilities among participants in the learning ecosystem. Through multi-directional arrows, the framework demonstrates how AI functions as both a mediating tool and a transformative agent, influencing

knowledge construction, curriculum adaptation, and entrepreneurial mindsets. Mediating variables such as digital literacy, institutional readiness, and technological infrastructure shape the effectiveness of AI integration, whereas moderating variables like policy support and socio-economic context determine the extent of impact on curriculum transformation and learner outcomes. Overall, this framework provides a holistic analytical lens to examine how human, technological, and institutional elements interact to foster innovation-driven entrepreneurship education within emerging economies. Figure 1 illustrates this framework:

Figure 1. Conceptual framework based on Activity Theory for AI-Driven Entrepreneurship Education and Curriculum Transformation.

Method

Research Design

This study employed a Systematic Bibliometric Analysis (SBA) to examine and visualise the intellectual, conceptual, and thematic structures of research situated at the intersection of Artificial Intelligence (AI), Entrepreneurship Education, and Curriculum Transformation, with particular attention to the Global South. The SBA approach combines the methodological rigour of a systematic review with the quantitative precision of bibliometric mapping, thereby ensuring comprehensive coverage and analytical depth (Donthu et al., 2021; Zupic & Čater, 2015). The methodological process adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) framework (Page et al., 2021), which provides a transparent and replicable structure for identifying, screening, and including relevant studies. This design allowed for the integration of descriptive bibliometric indicators with interpretive thematic synthesis, offering a multidimensional understanding of how AI-related scholarship informs entrepreneurship education and curriculum reform (Aria & Cuccurullo, 2017).

Data Sources and Search Strategy

Data for this study were extracted from three multidisciplinary and high-impact academic databases, namely Scopus, Web of Science (WoS), and JSTORE. The inclusion of multiple databases ensured broad coverage across education, management, and technology disciplines (Donthu et al., 2021). The search period extended from January 2019 to December 2024. Although the bibliometric dataset was initially extracted in July 2025, the analysis was restricted to publications indexed up to the end of 2024, which represents the most recent completed publication year. Restricting the dataset to 2024 ensures methodological reliability and avoids the instability of partially indexed records for 2025 in bibliometric databases such as Scopus and Web of Science, to capture the post-Fourth Industrial Revolution and post-COVID-19 surge in AI-related research in higher education (García-Morales et al., 2021). The database extraction was conducted in July 2025, which allowed sufficient time for 2024

publications to be fully indexed across databases. The search strategy combined key terms and Boolean operators as follows: ("Artificial Intelligence" OR "AI") AND ("Entrepreneurship Education" OR "Entrepreneurial Learning") AND ("Curriculum Transformation" OR "Curriculum Development" OR "Pedagogical Innovation") AND ("Higher Education" OR "Universities"). To ensure quality and relevance, filters were applied to include only peer-reviewed journal articles, conference papers, and book chapters published in English. Non-scholarly material such as dissertations, reports, and editorials was excluded. For the purposes of this study, the Global South refers to developing and emerging economies across Africa, Latin America, Asia, and parts of the Middle East. Country classifications were based on commonly used development studies frameworks and international economic groupings. Author affiliations extracted from the bibliographic records were categorised according to Global North and Global South classifications to analyse geographical research contributions.

## Inclusion and Exclusion Criteria

To maintain methodological consistency, studies were included if they examined AI applications or implications for entrepreneurship education or curriculum transformation, focused on higher education or university-level learning, were published between 2019 and 2024, and provided evidence or discussion relevant to the Global South or comparable developing contexts. Studies were excluded if they focused on AI in primary or secondary education, addressed entrepreneurship without reference to educational contexts, or were non-peer-reviewed or lacking analytical substance. Following the PRISMA stages of identification, screening, eligibility, and inclusion, an initial total of 426 records was retrieved (Scopus = 238; WoS = 128; JSTORE = 60). After the removal of duplicates and the application of inclusion criteria, 253 articles were retained for bibliometric and thematic analysis.

Data Extraction and Processing

Bibliographic data such as titles, authors, publication years, journal names, institutional affiliations, keywords, and citation counts were exported in BibTeX and CSV formats. Data cleaning and standardisation were undertaken using EndNote and Microsoft Excel to ensure accuracy and consistency in author names, institutional details, and keyword terminology. Two analytical tools were utilised for data processing and visualisation: the Bibliometrix R-package (version 4.1) for performance and science mapping indicators (Aria & Cuccurullo, 2017), and VOSviewer (version 1.6.20) for the visual representation of co-authorship, co-citation, and keyword co-occurrence networks (Van Eck & Waltman, 2010). Duplicate records were identified through automated matching of titles, author names, and Digital Object Identifiers (DOIs) using reference management software. Following automated filtering, a manual screening process was conducted to verify article relevance and remove remaining duplicates. Two independent reviewers examined titles, abstracts, and keywords to ensure alignment with the inclusion criteria. Any discrepancies were resolved through discussion to ensure consistency and reliability in the dataset.

Bibliometric Analysis Procedures

The bibliometric analysis unfolded across three principal dimensions. The performance analysis quantified the productivity and impact of sources, authors, countries, and institutions, thereby revealing the structural composition of the field (Donthu et al., 2021). The science mapping phase employed co-authorship, co-citation, and bibliographic coupling techniques to identify collaboration patterns and intellectual linkages among scholars (Zupic & Čater, 2015). The thematic evolution analysis examined keyword co-occurrence to trace the emergence and development of research themes, with specific focus on AI-enabled pedagogy, digital transformation, and innovation ecosystems in the Global South. Network visualisations were generated to illustrate the relationships among concepts and thematic clusters. The strength of the linkages between nodes was determined by co-occurrence frequency and normalised total link strength (Van Eck & Waltman, 2010). To ensure transparency and replicability in the network visualisations, specific threshold parameters were applied during the analysis using VOSviewer. In the keyword co-occurrence analysis, a minimum occurrence threshold of five (5) keywords was set, meaning that only keywords appearing at least five times across the dataset were included in the network map. This filtering resulted in the inclusion of the most relevant and frequently occurring terms representing the conceptual structure of the field. For the citation and co-citation analyses, a minimum citation threshold of ten (10) citations per document or source was applied to ensure that only influential publications contributed to the cluster formation. The clustering algorithm implemented in VOSviewer, based on the association strength normalisation method, was used to group related nodes into clusters. These threshold values were selected to balance network clarity with analytical depth, ensuring that the visualised clusters represent meaningful thematic relationships within the bibliometric dataset.
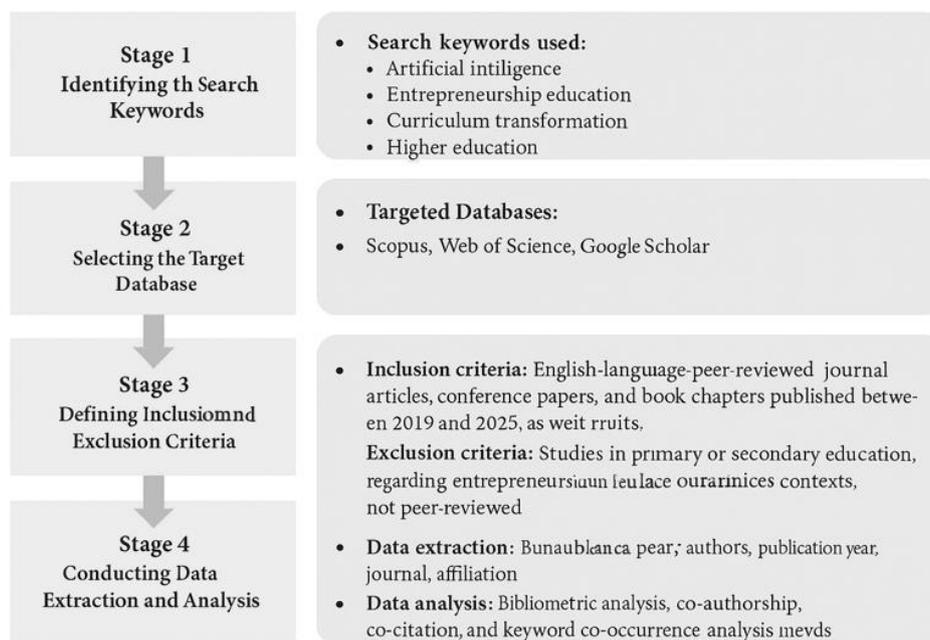
Figure 2. Four-stage Methodological Framework Used for Data Collection and Analysis.

Qualitative Thematic Integration

To complement the quantitative results, a qualitative thematic synthesis was undertaken to interpret the conceptual significance of the identified clusters. Following Braun and Clarke's (2019) thematic analysis framework, the process involved familiarisation with the data, coding, theme generation, refinement, and interpretation. The synthesis revealed three overarching thematic domains, namely AI-driven pedagogical innovation, curriculum transformation and digitalisation, and entrepreneurship education in the Global South. This integrative process ensured that the bibliometric findings were contextualised within broader theoretical and pedagogical debates.

Validity, Reliability, and Ethical Considerations

Methodological validity was maintained through the triangulation of data sources and analytical tools, thereby reducing the likelihood of source bias (Snyder, 2019). Reliability was enhanced through transparent documentation of the search strategy, inclusion criteria, and analytical procedures, consistent with PRISMA guidelines. As the study relied solely on secondary data, no ethical clearance was required. Nonetheless, all research integrity principles, including accurate citation, transparency, and responsible data management, were rigorously observed.

Summary

The Systematic Bibliometric Analysis applied in this study integrates the methodological strength of systematic review with the analytical power of bibliometric mapping. By synthesising publication trends, thematic patterns, and intellectual linkages, the approach provides a comprehensive understanding of how AI is influencing entrepreneurship education and curriculum transformation. It also highlights how research emerging from the Global South contributes to the reconfiguration of higher education towards more inclusive, innovative, and digitally adaptive systems.

Data Extraction and Analysis

This section presents the analysis of VOS Viewer and Bibliometric data extracted from Scopus, Web of Science, and JSTORE. It highlights publication trends, influential contributors, thematic patterns, and collaborative networks that define the research landscape on AI, entrepreneurship education, and curriculum transformation.

Distribution and Source Analysis

The bibliometric analysis reveals a steady increase in scholarly output examining the intersection of Artificial Intelligence (AI), entrepreneurship education, and curriculum transformation. A total of 253 publications were identified between 2019 and 2024 across Scopus, Web of Science, and JSTOR. As illustrated in Figure 4, the

annual distribution of publications indicates a gradual rise from 2019 to 2021, followed by a more pronounced growth from 2022 onwards. This increase coincides with the acceleration of digital transformation in higher education following the COVID-19 pandemic, which intensified scholarly attention on technology-mediated learning environments. The upward trajectory of publications suggests that the integration of AI into entrepreneurship education has emerged as a rapidly expanding interdisciplinary research domain. Early publications primarily addressed digital learning tools and online entrepreneurship education, whereas more recent studies increasingly explore AI-enabled pedagogical innovation, adaptive learning systems, and data-driven curriculum design. This pattern indicates a transition from exploratory discussions of digitalisation toward more advanced investigations of AI-supported teaching and learning processes in higher education.

Timespan 2019:2024	**Sources** 82	**Documents** 253	**Annual Growth Rate** 28.88 %
Authors 498	**Authors of single-authored docs** 79	**International Co-Authorship** 7.905 %	**Co-Authors per Doc** 2.09
Author's Keywords (DE) 935	**References** 10345	**Document Average Age** 3.88	**Average citations per doc** 4.775

Figure 3. Main Information.
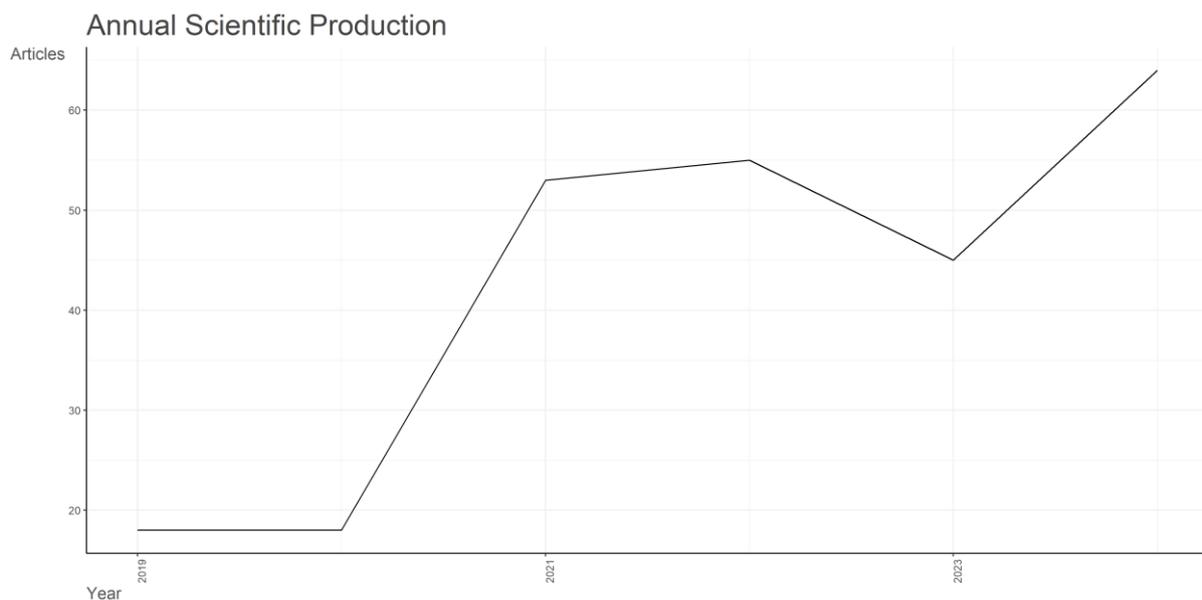
Figure 4. Annual distribution of publications on AI, entrepreneurship education, and curriculum transformation.
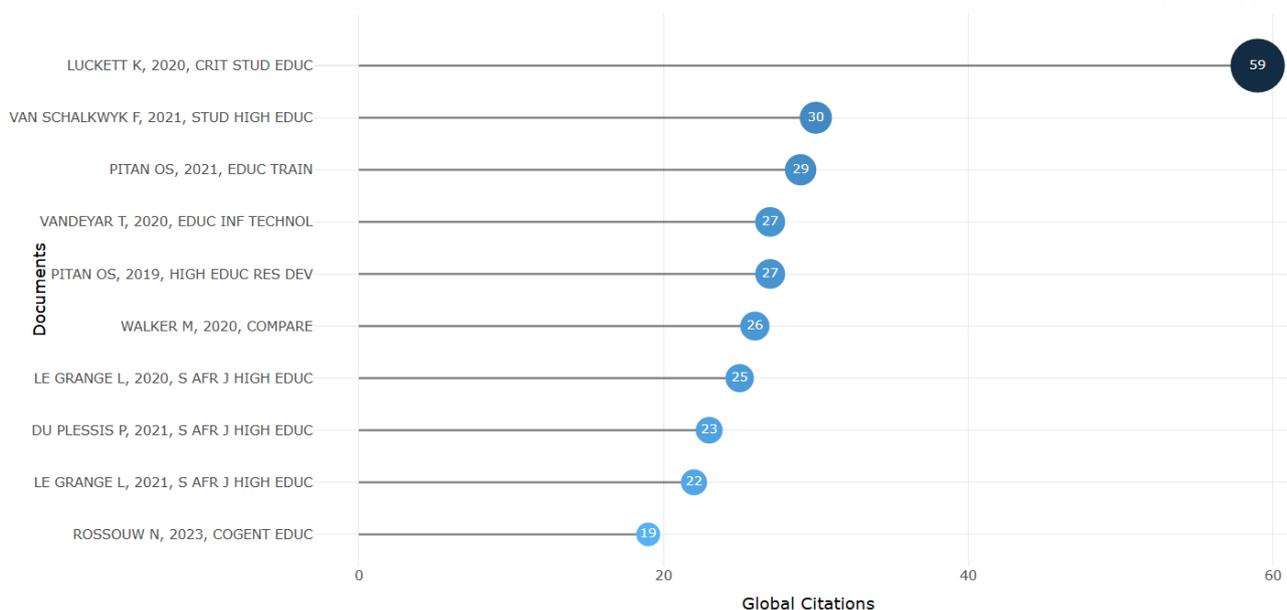
Figure 5. Most cited Documents.
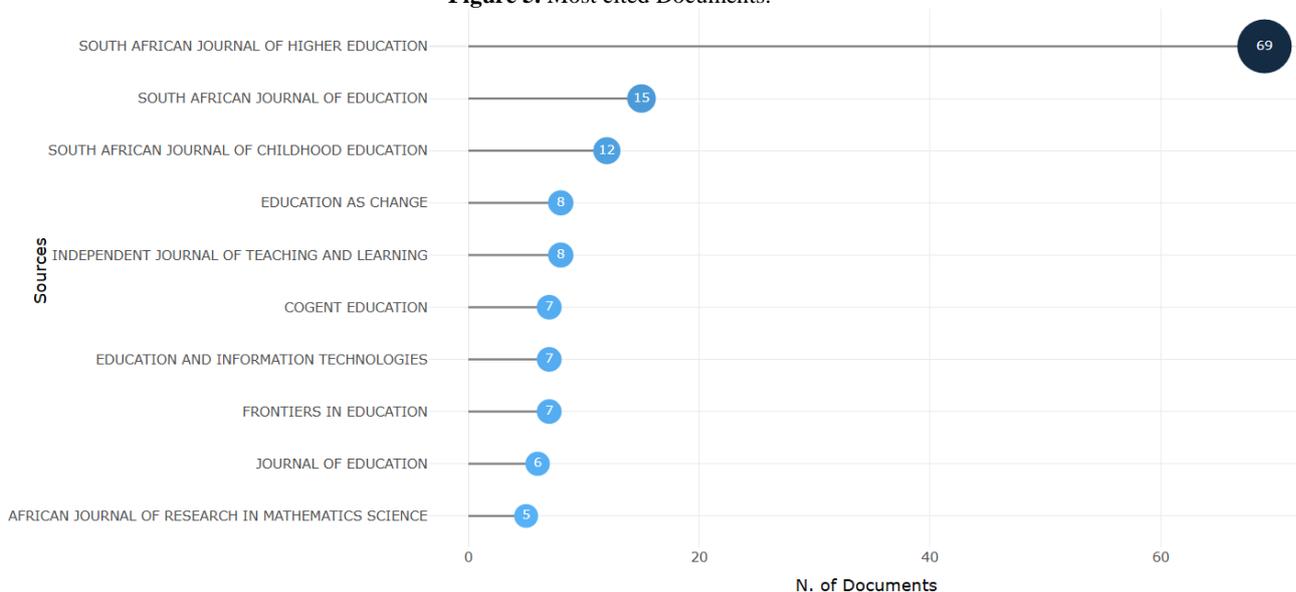
Figure 6. Most relevant sources.

Geographical, Institutional, and Author Collaboration Patterns

The performance analysis highlights a concentration of scholarly contributions within a relatively small group of authors, institutions, and countries. The analysis of institutional affiliations (Figure 8) identifies several universities as key contributors to research on AI-driven entrepreneurship education. These institutions often demonstrate strong interdisciplinary collaboration between education, management, and information technology departments. Country-level analysis (Figures 7, 9, and 10) reveals significant geographical disparities in research output and influence. South Africa emerges as the most influential country within the Global South, recording the highest citation count in the dataset with 1,147 citations. Other countries such as Nigeria, Ghana, Ethiopia, Namibia, and Kenya contribute to the field but with considerably lower citation impact. The collaboration network visualisation (Figure 9) indicates increasing international research partnerships, particularly between scholars in the Global South and institutions in the Global North. These collaborations facilitate knowledge exchange and methodological innovation, reflecting the growing globalisation of research on digital entrepreneurship education.
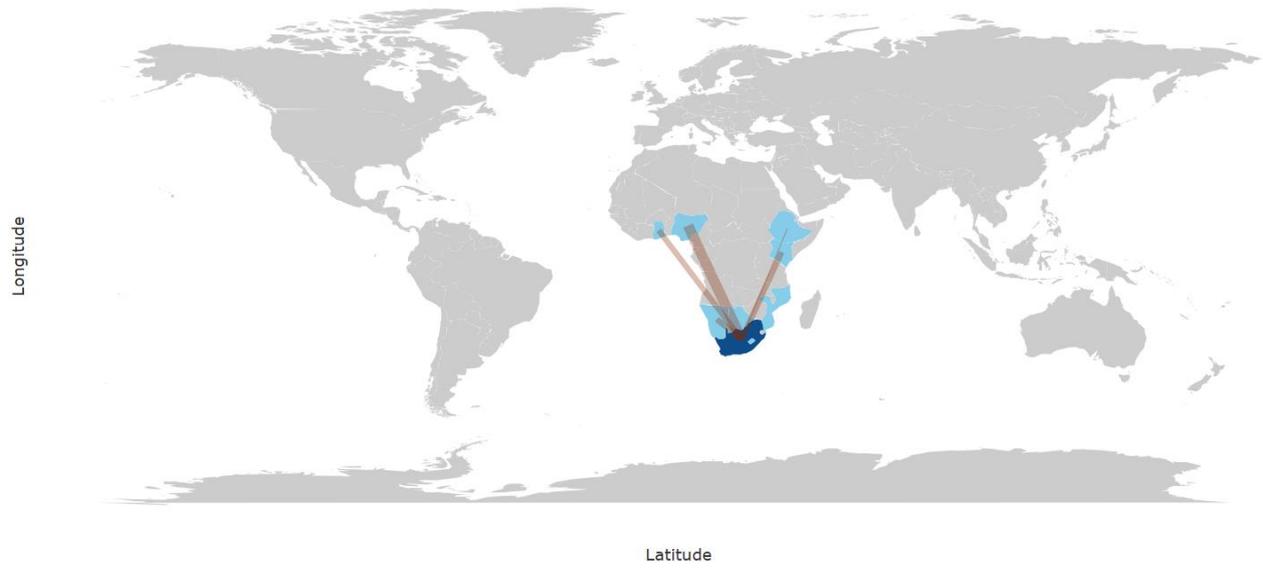
Figure 7. Countries' Collaboration World Map.
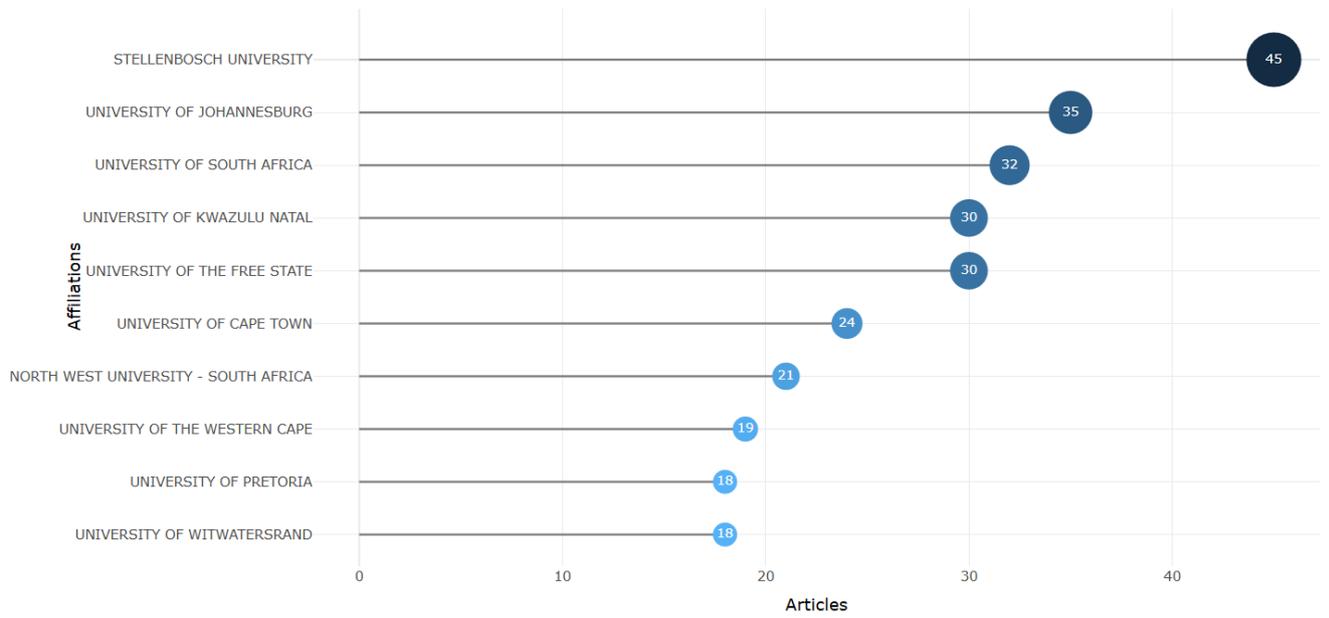
Figure 8. Most relevant affiliations.
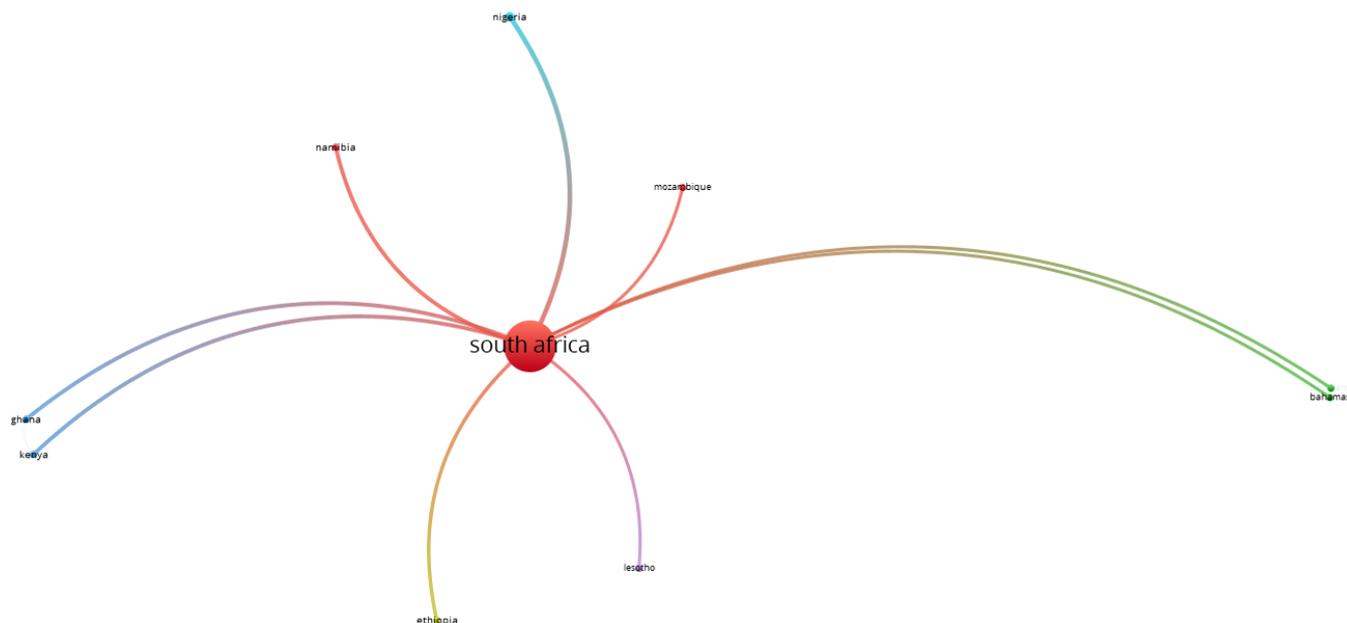
Figure 9. Co-Authorship by country.
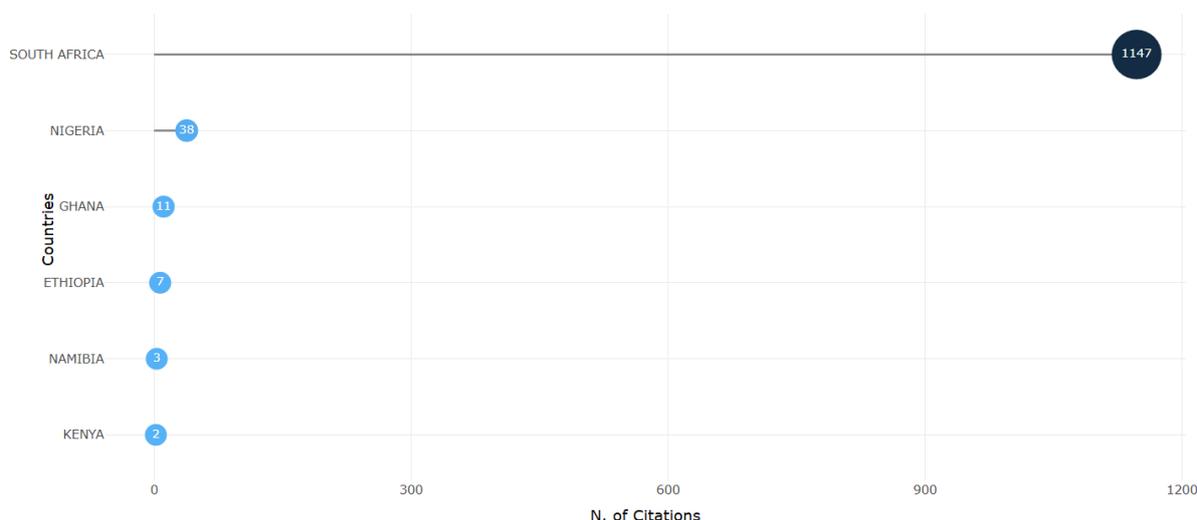
Figure 10. Most cited countries.

Citation, Co-occurrence, and Thematic Analysis

Citation analysis provides insights into the intellectual influence of journals and publications within the research field. Figure 5 identifies the most cited documents, while Figure 12 illustrates the journals that exert the greatest citation impact. The findings indicate that journals specialising in educational technology, innovation studies, and entrepreneurship research dominate the citation landscape. Highly cited publications typically focus on the transformative potential of AI in teaching and learning, digital entrepreneurship education models, and curriculum redesign in response to technological change. The prominence of these journals reflects the interdisciplinary nature of the field, where contributions span multiple academic domains including education, management, digital innovation, and technology studies. This interdisciplinary orientation highlights the complex and multifaceted nature of curriculum transformation in the digital era. The keyword co-occurrence network generated using VOSviewer reveals several interconnected thematic clusters that shape the research landscape. The largest cluster centres on education and higher education, linking key concepts such as students, teachers, institutions, and knowledge, which indicates that the literature is strongly grounded in higher education systems and pedagogical contexts. A second cluster focuses on student experiences and perceptions, including themes such as graduate employability, learning outcomes, and the impact of educational practices, suggesting an emphasis on how students engage with evolving educational environments. A third cluster highlights policy and socio-institutional dynamics, incorporating keywords such as policy, justice, capabilities, and coloniality, reflecting growing scholarly interest in issues of educational equity, governance, and transformation within higher education. Finally,

a smaller but interconnected cluster relates to student wellbeing and performance, linking terms such as stress, emotions, resilience, and academic performance. Together, these clusters illustrate that the literature is characterised by an interdisciplinary focus on higher education transformation, student development, institutional policy, and socio-cultural dynamics shaping contemporary educational systems.
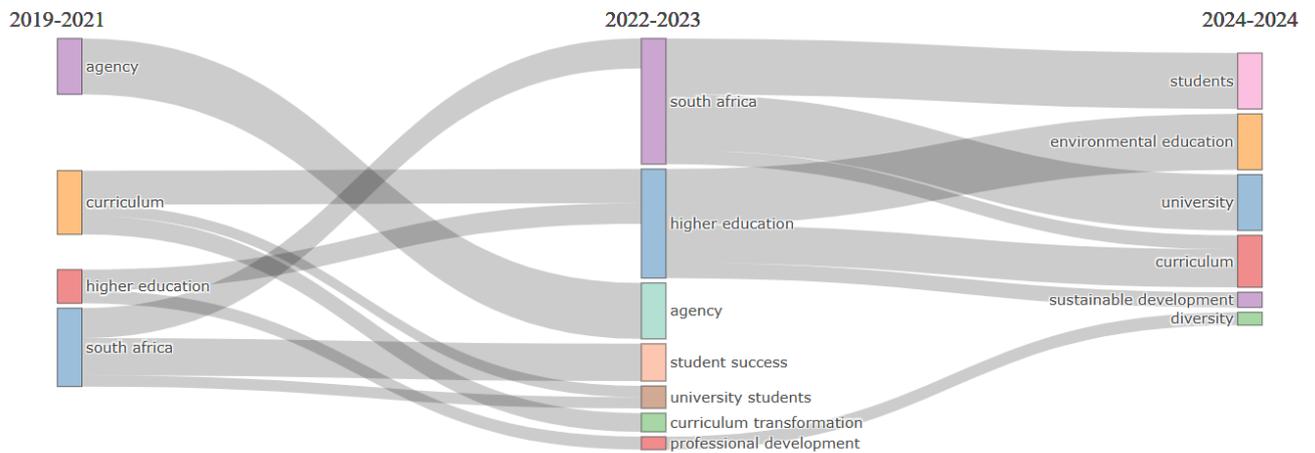
Figure 11. Thematic Evolution.
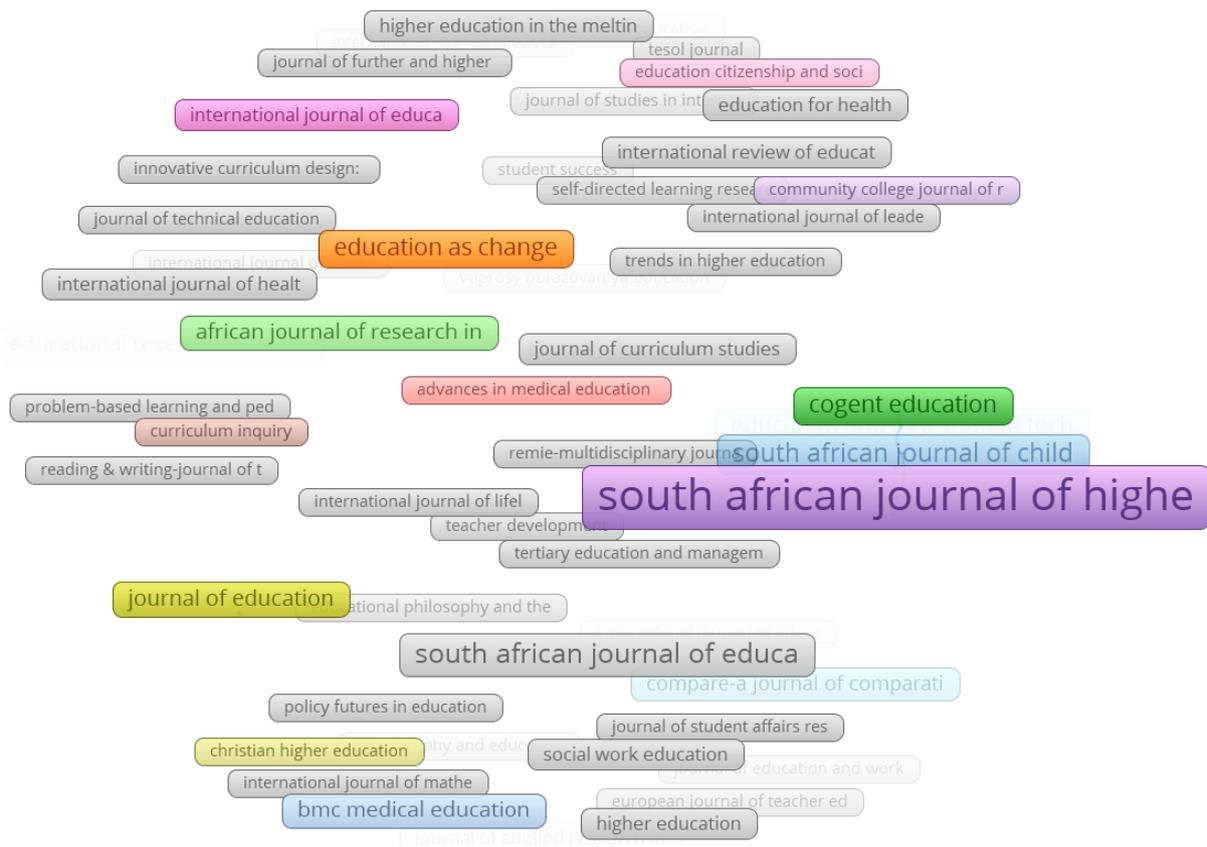
Figure 12. Citation by sources.

Figure 13. Keywords occurrences.

Analysis summary

The diagram titled *"Bibliometric Analysis"* provides an overview of the methodological framework used in bibliometric research. It integrates four key components: methods, analysis design, software, and outcomes. The methods section distinguishes between *backward* and *forward* analysis and includes techniques such as citation, co-citation, bibliographic coupling, and co-authorship. These are complemented by content analysis approaches conventional, directed, and summative which add qualitative interpretation. The analysis design centres on *bibliometric analysis* leading to *visualisation* and *content analysis*, showing how quantitative data can be translated into conceptual insights. The software tools listed such as Excel, BibExcel, Sitkis, HistCite, VOSviewer, CiteSpace, Gephi, UCINET, and iGraph support different stages of analysis and visualisation. Finally, the outcomes illustrate what each approach yields: identifying top articles and journals, mapping intellectual structures, tracking knowledge diffusion and development over time, detecting emerging literature, analysing collaboration impact, and revealing conceptual dynamics. Overall, the figure demonstrates how bibliometric analysis combines methodological rigour with data visualisation and software tools to produce a holistic understanding of research landscapes and scholarly influence.

Figure 14. Bibliometrics summary.

The diagram illustrates how VOSviewer functions in bibliometric analysis (see Figure 15 below). It connects various methods such as citation, co-authorship, and co-citation with the software's analytical role. Within the analysis design, VOSviewer facilitates network visualisation and mapping. The resulting outcomes include cluster analysis, mapping of research networks, heatmaps, and temporal analysis, which together reveal collaboration intensity, thematic structures, and the evolution of research over time.
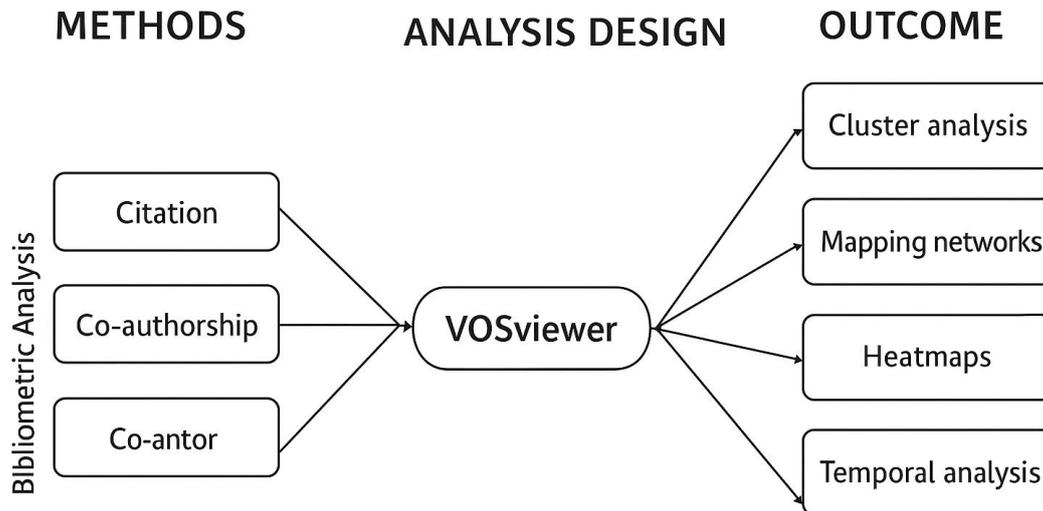
Figure 15. VOS summary.

Results

The qualitative thematic synthesis conducted on the bibliometric dataset identified four dominant thematic domains describing how artificial intelligence is being incorporated into entrepreneurship education and curriculum design in higher education institutions within the Global South. These themes emerged from the analysis of keyword co-occurrence patterns, publication content, and cluster relationships identified through the bibliometric mapping process.

AI-Driven Pedagogical Innovation

The first theme identified in the dataset relates to the use of artificial intelligence technologies to support pedagogical innovation in entrepreneurship education. The analysed studies report the increasing use of AI-enabled educational technologies such as intelligent tutoring systems, adaptive learning platforms, machine learning analytics, and generative AI tools to support teaching and learning processes (Scholtz, 2020). Several publications describe the integration of personalised learning environments that allow course content and learning activities to be adjusted according to individual student performance and engagement patterns (Matiki et al., 2023; Dlamini, Bayaga & Moyo, 2021). These AI-supported systems are used to generate automated feedback, monitor learner progress, and provide customised learning pathways within entrepreneurship programmes. The literature also reports the use of AI-based analytics to track student participation, evaluate learning behaviour, and support real-time instructional adjustments by educators (Mkhwanazi et al., 2021; Govender, 2022). In addition, a number of studies highlight the use of digital simulation environments, virtual entrepreneurship labs, and AI-supported case analysis tools that allow students to experiment with entrepreneurial decision-making in controlled digital environments. These platforms are used to simulate market scenarios, financial modelling, and venture development processes within entrepreneurship curricula.

Curriculum Transformation and Digitalisation

The second theme emerging from the analysis concerns curriculum transformation and the digitalisation of entrepreneurship education programmes. Publications within this cluster report the restructuring of course content, programme design, and assessment methods to incorporate artificial intelligence competencies and digital entrepreneurship skills (Rambe, 2023; Simba et al., 2024). The literature indicates that several higher education institutions have introduced new curriculum components focusing on AI literacy, data-driven decision-making, algorithmic thinking, and digital innovation (Mpungose, 2020). In many cases, these curriculum changes involve the integration of interdisciplinary modules combining entrepreneurship, information technology, and digital innovation studies. The analysed studies also report the use of digital platforms for course delivery, including learning management systems, virtual incubators, and online innovation labs that support collaborative project development (Pitan & Muller, 2019; Mukwambo, 2021;). Assessment practices reported in the literature include digital portfolios, AI-assisted feedback systems, and project-based entrepreneurial assignments conducted through online collaboration platforms (Dzamesi & van Heerden, 2020; Dubay & Richards, 2024). In addition, Dubay & Richards (2024) describe the redesign of entrepreneurship curricula to incorporate experiential learning activities supported by digital technologies, including virtual business simulations, digital venture creation projects, and online innovation challenges.

Entrepreneurship Education in the Global South

A third thematic domain emerging from the analysis relates to the contextual implementation of AI-supported entrepreneurship education within Global South higher education systems. Publications within this cluster document the institutional, infrastructural, and policy environments influencing the adoption of digital and AI-enabled educational practices (Nongqwenga & Funda, 2024). The literature reports variations in digital infrastructure availability across institutions, including differences in internet connectivity, access to digital learning platforms, and availability of AI-enabled educational technologies (Pika, 2024). Several studies identify disparities between urban and rural institutions with respect to technological resources and institutional readiness for digital transformation (Lynn et al., 2020; Omweri, 2024). Other publications describe institutional initiatives aimed at introducing digital entrepreneurship training programmes and technology-supported innovation ecosystems within universities (Şahin & Ozturk, 2019; Hanumantharaju & Sivakumar, 2024). These initiatives include partnerships with technology companies, innovation hubs, and entrepreneurship incubators designed to support digital venture development among students (Banele, Gomera & Kabelele, 2023). The studies also document the introduction of national and institutional strategies aimed at strengthening digital capacity in higher

education systems, including initiatives to expand digital infrastructure, develop technology-enabled teaching practices, and integrate emerging technologies into academic programmes (Aleryani, 2024).

Innovation Ecosystems and Research Collaboration Networks

The fourth theme emerging from the dataset concerns the development of innovation ecosystems and collaborative research networks associated with digital entrepreneurship education. Bibliometric mapping of co-authorship and institutional collaborations reveals increasing levels of international research cooperation within this field. The collaboration networks indicate partnerships between universities, research centres, and technology institutions across multiple regions. Several publications report joint research initiatives, collaborative curriculum development projects, and cross-institutional entrepreneurship education programmes supported through international partnerships (Christiansen, Juebei & Xiangyun, 2023). In addition, the literature describes the development of university-based innovation ecosystems that connect entrepreneurship education programmes with technology incubators, start-up accelerators, and industry partners (Maritz, Nguyen & Ivanov, 2022; Rambe & Hinson, 2024). These ecosystems are used to support student innovation projects, technology transfer activities, and digital venture creation initiatives (Aleryani, 2024). Network analysis also identifies a number of institutional clusters engaged in collaborative research related to artificial intelligence in higher education, entrepreneurship education, and digital innovation. These collaborations frequently involve partnerships between institutions in the Global South and Global North.

Discussion

The discussion reveals a dynamic intersection between Artificial Intelligence (AI), curriculum transformation, and entrepreneurial pedagogy in South African higher education. The literature underscores a growing institutional awareness of how AI-driven pedagogical innovation redefines traditional teaching frameworks while fostering creativity and problem-solving in entrepreneurship education (Bayaga, 2025). Within this context, AI tools function not merely as instructional aids but as catalysts for rethinking the epistemic and structural foundations of curricula. This shift supports the view that teaching and learning are evolving into more adaptive, data-driven, and learner-centred processes that align with the demands of the Fourth Industrial Revolution (Walwyn & Combrinck, 2025). However, as Luckett (2025) cautions, the integration of technology within curriculum reform must be situated within a decolonial framework that resists reproducing Eurocentric epistemologies. Studies on decoloniality and curriculum reform demonstrate that the historical residues of colonial education policy continue to influence knowledge hierarchies, thereby constraining efforts toward epistemic justice. This is consistent with Walker (2024), who calls for a capabilitarian approach that foregrounds equity, justice, and social inclusion as the foundation for curriculum innovation. Similarly, Koopman and Koopman (2025) identify the neoliberal technological epoch as a double-edged force expanding access to digital education while reinforcing market-oriented logics that often overlook contextual needs in the Global South.

Curriculum transformation efforts are particularly salient in the South African context, where educators and policymakers grapple with aligning pedagogical innovation with social justice imperatives. Erasmus and Bloem (2025) highlight how transformative developmental curricula, particularly in social work education, can promote equity and justice in highly unequal societies. Their findings resonate with Senekal's (2025) notion of "curriculum-in-motion," which advocates for learning grounded in community-based participatory research and lived experience. Both studies emphasise that meaningful curriculum reform must extend beyond policy rhetoric to embrace experiential, community-engaged pedagogies that reflect local realities. The role of technology and digitalisation in teacher education emerges as a critical enabler of transformation. Jita and Dhliwayo (2025) demonstrate how the use of tablets and design-based research frameworks fosters professional growth among teacher educators through communities of practice. This aligns with Bayaga (2025), who advocates for AI-enhanced pedagogical innovations that personalise learning experiences and support continuous professional development. Yet, the digital divide persists as a major constraint. Studies such as Mdodana-Zide and Chimbi (2025) and Govender (2025) show that rural and under-resourced ecosystems face persistent infrastructural barriers that hinder sustainable technology integration.

Institutional readiness and professional development remain recurrent challenges in the literature. Mkhwanazi et al. (2025) and Pillay (2025) both examine the Jika iMfundo initiative, revealing that while curriculum tracking and structured professional development programmes are designed to improve learning outcomes, their effectiveness is often limited by superficial compliance rather than genuine pedagogical engagement. Teachers frequently perceive such interventions as administrative exercises rather than opportunities for reflective practice and growth.

Similarly, Moyo, McKenna, and Ndebele (2025) observe that many university teaching grants are spent on projects grounded in common-sense assumptions rather than robust pedagogical theory, limiting their transformative potential. In the field of entrepreneurship education, collaborative ecosystems and international partnerships are emerging as crucial drivers of innovation. America and Neethling (2025) illustrate how activity theory-informed collaborations between South African and Dutch students enhance entrepreneurial awareness through experiential, cross-cultural engagement. This form of digital collaboration not only bridges the theory-practice divide but also strengthens global learning networks an observation echoed in the bibliometric mapping of growing North-South research partnerships. Such initiatives underscore that collaboration, when rooted in mutual learning and contextual sensitivity, can significantly enrich entrepreneurial education.

Bouwer (2025) and Pitan and Muller (2025) further contextualise these dynamics within broader higher education reform. Bouwer's study on decolonising tourism curricula highlights the necessity of stakeholder engagement, contextualisation, and multilingualism in shaping inclusive and responsive programmes. Similarly, Pitan and Muller (2025) underscore the importance of aligning employability development with curriculum design, ensuring that higher education responds effectively to evolving labour market demands. Together, these perspectives reveal that curriculum transformation in South Africa must be multi-layered integrating AI-driven innovation, decolonial reorientation, and contextually grounded employability strategies. Finally, the management of student success within restructured curricula also warrants attention. Ogude et al. (2025) illustrate how Extended Curriculum Programmes (ECPs) can promote access and equity through structured student support systems such as the Mamelodi Referral System. These models highlight that pedagogical innovation, and digital transformation must operate in tandem with student-centred management systems to ensure sustainable impact. Collectively, the reviewed studies reaffirm that AI and digitalisation hold transformative potential for South African higher education. However, their success depends on the coalescence of technological capacity, decolonial intent, institutional readiness, and inclusive collaboration across all levels of the educational ecosystem. The bibliometric findings reveal three major research trajectories in the field. First, scholarship increasingly focuses on the integration of artificial intelligence within entrepreneurship education as a driver of pedagogical innovation. Second, a growing body of literature addresses curriculum transformation and digitalisation within higher education institutions. Third, research emerging from Global South contexts highlights structural challenges such as digital infrastructure limitations, policy gaps, and unequal access to technological resources. These trends suggest that the intersection of AI and entrepreneurship education is evolving as a multidisciplinary field shaped by technological, institutional, and socio-economic factors.

Implications

Theoretical Implications

The findings reinforce the need to advance theoretical frameworks that integrate AI-enhanced pedagogy with decolonial and context-sensitive approaches to curriculum design. The studies reviewed highlight gaps in conventional pedagogical theories, which often fail to account for socio-economic, infrastructural, and epistemic inequities prevalent in Global South contexts (Luckett, 2025; Walker, 2024). Incorporating activity theory, design-based research, and critical pedagogy provides a nuanced lens to understand how AI and collaborative learning ecosystems mediate knowledge production, learner engagement, and entrepreneurial thinking (America & Neethling, 2025; Jita & Dhliwayo, 2025). Consequently, this body of work encourages scholars to develop hybrid theoretical models that simultaneously address technological affordances, social justice, and culturally responsive pedagogy.

Practical Implications

For practitioners, the findings highlight the critical need for structured, contextually relevant professional development that goes beyond superficial compliance and tick-box exercises. Teacher educators and higher education faculty require practical training in AI-driven pedagogy, collaborative learning platforms, and curriculum design frameworks to translate theoretical insights into classroom impact (Bayaga, 2025; Jita & Dhliwayo, 2025). The research also points to the value of leveraging international collaborations and experiential learning initiatives to cultivate entrepreneurial competencies, while simultaneously embedding local knowledge and sustainability practices (America & Neethling, 2025; Bouwer, 2025). Institutions should adopt adaptive and learner-centred management systems to monitor student progress and support successful implementation of digital and inclusive curricula (Ogude et al., 2025).

Policy Implications

The evidence underscores the importance of aligning national and institutional education policies with local realities to support effective curriculum transformation. Programmes such as Jika iMfundo and Extended Curriculum Programmes demonstrate that well-intentioned policy interventions may be undermined by misalignment between top-down mandates and teachers' classroom practices (Mkhwanazi et al., 2025; Pillay, 2025; Ogude et al., 2025). Policymakers should therefore prioritise consultative approaches that include educators and community stakeholders in designing and implementing curriculum innovations. Additionally, policies must facilitate equitable access to digital infrastructure, professional development resources, and AI-enabled tools to ensure that technology-driven initiatives do not exacerbate existing inequalities (Mdodana-Zide & Chimbi, 2025; Govender, 2025).

Limitations

While this study synthesises contemporary scholarship on AI-enhanced pedagogy and curriculum transformation, several limitations must be acknowledged. First, the focus on South African and select Global South contexts may limit the generalisability of findings to other regions with differing socio-political and infrastructural conditions. Second, the reliance on published studies from 2024 may exclude emerging interventions or informal practices that have not yet been captured in academic literature. Third, variations in research design, sample sizes, and methodological rigour across studies make it challenging to draw definitive causal conclusions. Finally, the review primarily considers English-language sources, potentially overlooking relevant research published in other languages or regional outlets.

Conclusion

This synthesis demonstrates that AI-driven pedagogical innovation, curriculum digitalisation, and collaborative learning ecosystems hold significant potential to transform higher education in the Global South. Successful implementation, however, requires integration of decolonial and context-sensitive approaches, robust policy alignment, and sustained professional development for educators. While challenges such as infrastructural inequities, superficial adoption of tools, and misalignment between policy and practice persist, evidence suggests that carefully designed interventions can enhance learner engagement, foster entrepreneurial competencies, and promote social justice. Ultimately, advancing higher education requires a multi-dimensional approach that simultaneously addresses technological, pedagogical, and socio-cultural factors, ensuring that innovation serves both learning outcomes and broader societal development goals.

Acknowledgements or Notes

Author (s) Contribution Rate

The author contributed 100% to all aspects of this study.

Ethical Approval

Ethical approval was not required for this study as it is based on a systematic literature review of previously published studies.

References

Aleryani, A. Y. (2024). Digital transformation in higher education in developing countries to promote sustainable development. *International Journal of Scientific and Research Publications*, *14*(2), 128-141.

America, C., & Neethling, A. (2025). International collaboration for the advancement of entrepreneurship education: An activity theory approach. *SunJournals.*

Aparicio, S., Urbano, D., & Audretsch, D. (2021). Institutional factors, opportunity entrepreneurship and economic growth: Panel data evidence. *Technological Forecasting and Social Change, 163*, 120419.

Aria, M., & Cuccurullo, C. (2017). Bibliometrix: An R-tool for comprehensive science mapping analysis. *Journal of Informetrics, 11*(4), 959–975.

Banele, S. D., Gomera, W. C., & Kabelele, D. P. (2023). Innovation hub a venture for students' entrepreneurial talents: a case of college of business education. *International Journal of Research in Business & Social Science*, *12*(5).

Bayaga, A. (2025). *Leveraging AI-enhanced and emerging technologies for pedagogical innovations in higher education.* Springer.

Bouwer, S. C. (2025). Decolonising tourism curricula: Voices from South Africa. *Routledge Journals, Taylor & Francis Ltd.*

Braun, V., & Clarke, V. (2019). Reflecting on reflexive thematic analysis. *Qualitative Research in Sport, Exercise and Health, 11*(4), 589–597.

Brix, J., & Jakobsen, H. (2020). Corporate entrepreneurship education: The case of higher education institutions. *Education + Training, 62*(4), 425–438.

Chen, L., Li, Y., & Wu, J. (2024). Artificial intelligence in entrepreneurship education: A scoping review. *Education + Training.*

Christiansen, S. H., Juebei, C., & Xiangyun, D. (2023). Cross-institutional collaboration in engineering education– a systematic review study. *European Journal of Engineering Education*, *48*(6), 1102-1129.

Crompton, H., Burke, D., & Gregory, K. (2023). Artificial intelligence in higher education: The state of the field. *International Journal of Educational Technology in Higher Education, 20*(1), 32–49.

Díaz-García, V., Sáiz-Manzanares, M. C., & Llamas-Nistal, M. (2022). Digitalisation and digital transformation in higher education: A bibliometric analysis. *Sustainability, 14*(17), 10721.

Dlamini, S., Bayaga, A., & Moyo, G. (2021). Imperatives of situating teacher and higher education in the context of the fourth inductrial revolution. *Higher educafion in the melfing pot: Emerging discourse of the 4IR and decolonisafion*, 31-44.

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research, 133*, 285–296.

Dubay, C. M., & Richards, M. B. (2024). Leveraging artificial intelligence in project-based service learning to advance sustainable development: A pedagogical approach for marketing education. *Marketing Education Review*, *34*(4), 307-323.

Dzamesi, F. E., & van Heerden, J. (2020). A professional development programme for implementing indigenous play-based pedagogy in kindergarten schools in Ghana. *South African Journal of Education, 40*(3).

Engeström, Y. (1987). Learning by expanding: An activity-theoretical approach to developmental research. Orienta-Konsultit.

Erasmus, L., & Bloem, R. (2025). Contents of a transformative developmental social work curriculum. *Routledge Journals, Taylor & Francis Ltd.*

Fayolle, A., Verzat, C., & Wapshott, R. (2020). In quest of legitimacy: The theoretical and methodological foundations of entrepreneurship education research. *International Small Business Journal, 38*(4), 391–414.

Fernández, A., Serrano, M., & Ortega, J. (2023). Digital transformation initiatives in higher education: Challenges and future perspectives. *Education and Information Technologies, 28*(4), 4753–4772.

Fossen, F. M., Sorgner, A., & Ziegler, A. (2024). Artificial intelligence and entrepreneurship: Opportunities and challenges. *Small Business Economics, 63*(2), 433–451.

García-Morales, V. J., Garrido-Moreno, A., & Martín-Rojas, R. (2021). The transformation of higher education after the COVID-19 disruption: Emerging challenges in teaching and learning. *Technological Forecasting and Social Change, 166*, 120620.

Govender, N. (2022). Preservice Science Teachers' Experiences of Food Garden Projects: Implications for Education for Sustainable Development (ESD) in Curriculum Transformation. *Journal of Contemporary Educational Studies/Sodobna Pedagogika*, *73*(2).

Govender, N. (2025). Preservice science teachers' experiences of food garden projects: Implications for education for sustainable development (ESD) in curriculum transformation. *Slovenian Association of Educationalists.*

Hanumantharaju, K. B., & Sivakumar, R. (2024). Journal of Contemporary Educational Research and Innovations. *Journal of Contemporary Educational Research and Innovations*, *14*(5), 60-67.

Holmes, W., Bialik, M., & Fadel, C. (2021). *Artificial intelligence in education: Promises and implications for teaching and learning.* Boston: Centre for Curriculum Redesign.

Jita, T., & Dhliwayo, A. (2025). Design-based approach to technology innovation: Teacher educators' experiences with tablets as instructional tools in South Africa. *Bastas Publications Ltd.*

Kaptelinin, V., & Nardi, B. A. (2006). Acting with technology: Activity theory and interaction design. MIT Press.

Khoza, N. G. (2022). A review of literature on the effective pedagogy strategies for online teaching and learning in higher education institutions: Lessons from the COVID-19 pandemic. *European Journal of Education (EJED)*, *5*(1), 43-55.

Khoza, N. G. (2024). Empowering female entrepreneurs in underprivileged communities through ai: exploring opportunities, challenges, and inclusive pathways: a case of Africa. *African Journal of Innovation and Entrepreneurship (AJIE)*, *3*(3), 193.

Koopman, O., & Koopman, K. J. (2025). *The impact of the neoliberal technological epoch and COVID-19 on the decolonisation of the university curriculum.* SunJournals.

Luckett, K. (2025). Racial discourses and colonial education policy: The discursive construction of education development at a historically white South African university. *SAGE Publications Ltd.*

Lynn, T., Rosati, P., Fox, G., Curran, D., O'Gorman, C., & Conway, E. (2020). Addressing the urban-town-rural divide: the digital town readiness assessment framework. In *ICDS 2020: The fourteenth international conference on digital society* (pp. 1-10).

Maritz, A., Jones, C., & de Waal, G. (2023). Rethinking entrepreneurship education: Digital technologies, innovation, and resilience. *Journal of Small Business and Enterprise Development, 30*(2), 287–304.

Maritz, A., Nguyen, Q., & Ivanov, S. (2022). Student entrepreneurship ecosystems at Australian higher education institutions. *Journal of Small Business and Enterprise Development*, *29*(6), 940-957.

Maritz, A., Perenyi, A., & de Waal, G. (2022). Digital entrepreneurship education: Pedagogical models and emerging trends. *Education + Training, 64*(6), 791–808.

Matiki, D. S., Chibambo, M. I., & Divala, J. J. (2023, September). A comparison of teacher's involvement in curriculum development in developing and developed countries: a case study of Namibia. In *Frontiers in Education* (Vol. 8, p. 1243573). Frontiers Media SA.

Matsieli, M., Mhlanga, D., & Moloi, T. (2024). COVID-19 and digital transformation in higher education: A social justice perspective. *Education Sciences, 14*(2), 104–118.

Mdodana-Zide, L., & Chimbi, G. T. (2025). *Transforming education in a rural ecosystem: School libraries as hubs for teaching-learning innovation.* Frontiers Media SA.

Mhlanga, D. (2023). The integration of artificial intelligence in higher education in the Global South: Opportunities and challenges. *African Journal of Science, Technology, Innovation and Development, 15*(4), 769–778.

Mkhwanazi, T., Ngcobo, A. Z., Ngema, S., & Bansilal, S. (2021). The curriculum tracker: A tool to improve curriculum coverage or just a tick-box exercise? *South African Journal of Education, 41*(2).

Moyo, T., McKenna, S., & Ndebele, C. (2025). How the Teaching Development Grant was used (and the problem of common-sense understandings of teaching and learning). *University of KwaZulu-Natal, School of Education and Development.*

Mpungose, C. B. (2020). Beyond limits: Lecturers' reflections on Moodle uptake in South African universities. *Education and Information Technologies, 25*(6), 5033–5052.

Mukwambo, P. (2021). Human development and perceptions of secondary education in rural Africa: A Zimbabwean case study. *Compare: A Journal of Comparative and International Education, 51*(6), 806-823.

Mwanza-Simwami, D. (2020). Activity theory as a lens for understanding digital transformation in higher education. Education and Information Technologies, 25(5), 4157-4171.

Nambisan, S., Lyytinen, K., Majchrzak, A., & Song, M. (2020). Digital innovation management: Reinventing innovation management research in a digital world. *MIS Quarterly, 44*(1), 1-14.

Nambisan, S., Wright, M., & Feldman, M. (2019). The digital transformation of innovation and entrepreneurship: Progress, challenges and key themes. *Research Policy, 48*(8), 103773.

Neck, H. M., Corbett, A. C., & Greene, P. G. (2021). How entrepreneurship education can engage students and build entrepreneurial mindsets. *Academy of Management Learning & Education, 20*(4), 453–474.

Nongqwenga, M., & Funda, V. (2024). A model to integrate Generative Artificial Intelligence to improve student academic performance in South African universities. In *International Conference on Emerging Technology and Interdisciplinary Sciences* (pp. 46-53).

Ogude, N. A., Majozi, P. C., Mathabathe, K. C., & Mthethwa, N. (2025). The management of student success in extended curriculum programmes: A case study of the University of Pretoria's Mamelodi Campus, South Africa. *SunJournals.*

Omweri, F. S. (2024). A systematic literature review of e-government implementation in developing countries: examining urban-rural disparities, institutional capacity, and socio-cultural factors in the context of local governance and progress towards SDG 16.6. *International Journal of Research and Innovation in Social Science*, 8(8), 1173-1199.

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., ... & Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ, 372*, n71.

Pika, S. T. (2024). Humanising digital pedagogy for equitable learning in South African rural universities. *Sustainable Development and Contemporary Issues in Society and Education*, 82(085), 106.

Pillay, V. (2025). Jika iMfundo: A South African study of 'turning education around' through improved curriculum coverage. *Routledge Journals, Taylor & Francis Ltd.*

Pitan, O. S., & Muller, C. (2019). University reputation and undergraduates' self-perceived employability: Mediating influence of experiential learning activities. *Higher Education Research & Development, 38*(6), 1269–1284.

Pitan, O. S., & Muller, C. (2025). *Student perspectives on employability development in higher education in South Africa.* Emerald Group Publishing Ltd.

Rambe, P. (2023). The flipped classroom effect on entrepreneurship education: Applying critical pedagogy in digital environments.

Rambe, P., & Hinson, R. E. (2024). The future of innovation and entrepreneurship as drivers of livelihoods in Southern Africa: A synthesis. In *The future of entrepreneurship in Southern Africa: Technological and managerial perspectives* (pp. 219-247). Cham: Springer Nature Switzerland.

Ratten, V., Jones, P., & Braga, V. (2021). Entrepreneurship education and the fourth industrial revolution. *Industry and Higher Education, 35*(6), 655–661.

Şahin, M. D., & Ozturk, G. (2019). Mixed method research: Theoretical foundations, designs and its use in educational research. *International Journal of Contemporary Educational Research*, 6(2), 301-310.

Scholtz, D. (2020). Qualifications development for an unknown future. Journal of Curriculum Studies, 52(3), 413-427.

Senekal, I. (2025). Curriculum-in-motion: Bringing community education to life through community-based participatory action research. *Unisa Press.*

Simba, A., Rambe, P., Navarrete, S. R., & Vadillo, M. T. P. (2024). A technostress–entrepreneurship nexus in the developing world. *International Entrepreneurship and Management Journal*, 20(3), 2019-2046.

Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. *Journal of Business Research, 104*, 333-339.

Van Eck, N. J., & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics, 84*(2), 523–538.

Vecchiarini, M., Jones, P., & Ratten, V. (2023). Redefining entrepreneurship education in the age of generative AI. *Industry and Higher Education, 37*(5), 524–538.

Vygotsky, L. S. (1978). Mind in society: The development of higher psychological processes. Harvard University Press.

Walker, M. (2024). A capabilitarian approach to decolonising curriculum. *Education, Citizenship and Social Justice*, 19(1), 110-123.

Walwyn, D. R., & Combrinck, C. (2021). Epistemic justice during a global pandemic: Transforming curricula and pedagogical practices to improve student experiences of innovation studies. *Industry and Higher Education*, 35(5), 598-608.

Wang, S., Wang, F., Zhu, Z., Wang, J., Tran, T., & Du, Z. (2024). Artificial intelligence in education: A systematic literature review. *Expert systems with applications*, 252, 124167.

Yamagata-Lynch, L. C. (2010). Activity systems analysis methods: Understanding complex learning environments. Springer.

Yende, S. J. (2025). *Performing arts: A case study on curriculum transformation.* Independent Institute of Education–IIE.

Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education. *International Journal of Educational Technology in Higher Education, 16*(1), 39–59.

Zupic, I., & Čater, T. (2015). Bibliometric methods in management and organisation. *Organizational Research Methods, 18*(3), 429-472.

The Impact of Anger Control and Zero Violence Training on Preventing Teacher Violence: A Quantitative Study from Timor-Leste

Salvador Magno Ximenes[1] | ⓘD | salvadormx2018@gmail.com
Instituto Católico para a Formação de Professores (ICFP), Education, Teacher Training, Baucau, Timor-Leste
Ágata Moreira Freitas | ⓘD | moreirafreitas81@gmail.com
Instituto Católico para a Formação de Professores (ICFP), Education, Teacher Training, Baucau, Timor-Leste
Crisogno Soares Freitas Pereira | ⓘD | crisognosoaresfreitasp@gmail.com
Instituto Católico para a Formação de Professores (ICFP), Education, Teacher Training, Baucau, Timor-Leste

Abstract

This study examines the impact of anger control and zero-violence training on the prevention of violent teaching among elementary school teachers in Timor-Leste, which can have implications for the professionalism of teachers and the safety of schools. The quantitative type of research was used, where an ANOVA and multiple regression analysis were performed to evaluate the data set of the sample of 40 trained teachers in the Baucau municipality. The result showed that zero-violence training has significantly improved teachers' approach to non-violent instructional practice in the classroom. In contrast, the Anger-Control Training did not generate a measurable effect. These findings suggest that system-based feature interventions that focus on classroom actions and relationships between educators and students are more efficient compared to separate programs for managing emotions. This study contributes to the international debate on violence-free education because it points out the significance of evidence-based but culturally appropriate teacher training in post-conflict situations. Reinforcements involve the incorporation of zero-violence training in both pre-service and in-service teacher preparation, the establishment of continuous professional monitoring, and the utilisation of the program in rural areas of Timor-Leste.

Keywords: Anger control, Zero-violence, Teacher training, Violent practice, Preventing violence.

Citation

Introduction

[1] Corresponding Author

Timor-Leste became independent in 2002, after centuries of colonial rule and many wars. Since then, the country's education system has had to deal with many major problems. The fact that violent teaching is still common is a sign of a major problem that harms both student welfare and academic standards. Historical elements of the country's past violence, along with traditional disciplinary traditions, normalise physical punishment with coercive teaching methods in educational institutions. Teachers had physically abused the 70% of students in the past year, and 80% of teachers agreed that physical punishment could be appropriate in some situations (Baumgarten, Simmonds & Mason-Jones, 2023). The problem needs to be resolved right away to make schools safe places to learn because teachers who aren't properly trained and who don't have enough resources have made things worse. When working on a solution, it's important to look closely at the reasons behind violent teaching and come up with answers that work with Timor-Leste's culture and school system.

Non-governmental organizations partnered with UNICEF to confirm that Timorese schools experience high frequencies of aggressive teaching practices, emotional mistreatment, and psychological manipulation. Educational personnel in multiple ways, including through physical violence, while also employing verbal and emotional mistreatment practices and failing to provide sufficient care. Children's human rights suffer from physical punishment while their learning abilities decline because they develop fear and classroom disinterest during this abuse. School violence causes people to develop persistent mental issues, leading to depression and anxiety, together with reduced self-esteem, according to the report of the World Health Organisation (2021). These school methods obstruct the critical thinking development and problem-solving capacities of students and restrict their academic growth (Ximenes, 2024). There is an urgent need to find effective intervention strategies to get rid of violent approaches in classrooms and make schools nonviolent places with respect at their core.

Educational organisations should establish anger control and zero-violence training programs for teachers as effective solutions for preventing student abuse. The programme intends to deliver alternative discipline techniques that respect students' rights, reduce aggression, and maintain their dignity through the adoption of positive classroom management approaches (Saputra, 2021). These kinds of programmes focus on training teachers how to better handle their emotions, helping them learn how to control themselves and understanding what children need as they grow up. The interventions obey the rules set by Timor-Leste's National Education Strategic Plan because they focus on creating peaceful learning spaces that encourage everyone to feel welcome (Ministry of Education, Youth and Sports (MoEYS), Timor-Leste, 2020). Teaching the changes in a culturally sensitive manner increases the likelihood of teachers agreeing with them. This will lead to long-lasting improvements in how they teach.

Timor-Leste continues to struggle with education system issues because violent teaching approaches are commonly found throughout its educational institutions. The study investigates the effect of zero-violence training programs along with anger control education as tools for preventing violent teaching behaviours in Timor-Leste's educational settings. The study combines research findings from existing studies regarding the subject matter while focusing on essential areas, along with lacking knowledge and prospects for future exploration. The education system of Timor-Leste has undergone development through centuries of Portuguese colonisation and Indonesian occupation, followed by a struggle for independence (Shah and Quinn, 2016). Throughout history, these factors developed an educational atmosphere that views corporal punishment together with school violence as natural disciplinary tools.

The Frequency and Impact of Violent Teaching Practices

Analysis of Timor-Leste's education system demonstrates the high occurrence of violent discipline methods causing students physical and academic harm through traditional teaching practices. A 2015 survey showed that physical violence between students and teachers was common; 70% of children said they had been abused by their teachers in the past year (UNICEF, 2015). The results of quantitative research show that violent forms of discipline are still used all over society. This is mostly because many people believe that teachers should be in charge and students should follow their lead. An investigation by Rees et al. (2015) found that teachers mostly used physical punishment and verbal abuse along with it as their main way of disciplining students. This made schools feel like places where students had to obey instead of actively learning. Teachers mostly use these methods of discipline because they haven't been properly trained in other, more positive ways to discipline students, especially in rural and underfunded areas. Several studies have created an alarming image of the educational conditions in Timor-Leste because they demonstrate both psychological injuries for students and national academic setbacks. These actions go against Timor-Leste's international promises to protect children because they violate the UN Convention on the Rights of the Child. The country needs to quickly change its policies and start training teachers (Global Initiative to End All Corporal Punishment of Children, 2023) to make this happen. The establishment of anger

control and zero-violence training for educators represents a vital solution to create safe educational spaces that put student dignity, along with full development, at the forefront.

The Negative Practices Impact on Students

The ongoing occurrence of violent educational techniques in Timor-Leste leads to serious detrimental effects on how students achieve academically, while damaging their psychological state and general growth. Multiple studies show that physical and verbal mistreatment in classrooms produces lowered academic achievement because students exposed to these methods develop fear and anxiety while losing their learning drive (Global Initiative to End All Corporal Punishment of Children, 2023). Students who experience fear in their learning environment turn off their learning capacity and develop impaired critical thinking abilities. Violence has negative effects on students, such as making them perform poorly in school, which limits their options for the future. Students who experience school violence drop out of education frequently because the insecure school environment makes them withdraw completely from their educational path (Global Initiative to End All Corporal Punishment of Children, 2023). Timor-Leste has problems because it is hard to get a good education, and kids drop out of school too soon, which worsens social problems and prevents the country from moving forward.

Acts of violence during student disciplinary actions cause serious psychological impacts in addition to causing substantial social problems. The data show that students who undergo corporal punishment and emotional abuse develop greater risks for enduring mental health problems, such as anxiety and depression and reduced self-esteem (Durrant & Ensom, 2012). The harmful effects that result from physical punishment interrupt academic commitment while preventing students from improving their relationship skills, establishing trust with supervisors, and developing personal confidence. Anti-social behaviours that schoolchildren learn from experiencing violence in schools tend to remain with them, which leads to an ongoing pattern of violence extending from families to communities. The need for immediate changes requires schools to develop and implement peaceful teaching practices that will create protective learning environments (Bradshaw et al., 2021). To achieve school disciplinary reform in Timor-Leste, the government should implement three main components: teacher training, policy changes, and public awareness initiatives (Ximenes, 2026a). The country must implement child-centred educational methods and teach respect and empathy to students in every subject, including mathematics (Ximenes, 2026b. This combination will help eliminate violent teaching methods and create an equitable educational environment for everybody.

Anger Control Training for Teachers

The current literature on anger control training for teachers in Timor-Leste remains scarce, but parallel settings demonstrate promising results. Wangdi & Namgyel's (2022) research results underline the importance of teachers' strategic classroom management methods in creating better classroom environments that produced less disruptive behaviour. Studies indicate that anger management programmes effectively lower adolescent anger while simultaneously developing their problem-solving and communication abilities, thus validating their potential effectiveness in the teacher population (Singh & Kaur, 2023). As Timor-Leste faces challenges, the government focuses on implementing programs that teach peace while fighting violence. Pre-service teacher trainers must be provided with modern pedagogical abilities to promote enduring peace throughout the country (Sayed & Novelli, 2016; Beck, 2024). According to Wild et al. (2022), education and early intervention are the keys to preventing violence toward children and women and creating a peaceful society in Timor-Leste. Therefore, establishing training programmes for anger control for teachers in Timor-Leste shows strong potential to decrease violent instructional behaviours and enhance the educational setting.

Zero Violence Training Programs

The objective of Zero Violence training programs is to build schools where violence does not exist. Research in cultural and geographical areas like Timor-Leste shows promising results that can help us think of ways to stop this from happening. The Brazilian "Escolas de Paz" (Schools of Peace) program succeeds in controlling school violence by teaching teachers non-violent mediation techniques (Amaral and Ramos, 2018). The implementation of successful prevention strategies in schools directly depends on thorough educator training (Sprague and Walker, 2021). Such evidence-based approaches need proper teacher training to work effectively. Positive Behavioural Intervention and Support (PBIS) stands alongside restorative practices, while social–emotional learning and trauma-informed care operate as additional approaches. According to the research, adapting parallel violence

prevention strategies to fit Timor-Leste's culture and educational setting would play a significant role in making classrooms peaceful for students.

Challenges and Contextual Factors in Timor-Leste

Some things about Timor-Leste's culture make it harder to carry out programs that teach people how to control their anger and avoid violence. A lack of teachers and poor infrastructure in the education system make it hard to provide more and longer-lasting anger management and zero-violence training (Shah and Quinn, 2016; Ximenes, 2025). Most people in Timor-Leste are okay with physical punishment. New ways of teaching that don't use physical punishment are hampered by the cultural norm of using it. Rees et al. (2022) show that Timor-Leste's traumatised past continues to affect its population by limiting teachers' and students' ability to accept nonviolent conflict resolution methods. All of these things show how important it is to have well-thought-out interventions that deal with both the current violent teaching practices and Timor-Leste's larger social and cultural background. A successful educational initiative for Timor-Leste would require elements that handle resource shortages, modify cultural beliefs, and deliver historical trauma remediation.

This study explores the impact of anger control and zero violence training on school teachers' capacity to avoid using violent teaching methods in Timor-Leste's educational context. The research questions revolved around the impact of implementing Anger Control and Zero Violence Training on teachers' adoption of non-violent instructional methods. What effects do programmes teaching anger control alongside zero violence training generate regarding educators' ability to regulate emotions while managing their classrooms in Timor-Leste? Anger Control and Zero Violence Training don't seem to have much of an effect on stopping teachers in Timor-Leste from using violence while teaching, according to the alternative hypothesis. H1: Anger management and Zero-Excessive Violence Training make a real difference in keeping teachers in Timor-Leste's schools from using violent methods of teaching. These research questions and hypotheses in this study support the overall mission of fostering an education system in Timor-Leste that develops empowered students who meet modern times' requirements. The establishment of non-violent educational settings remains vital to break the violence pattern and create the basis for Timor-Leste's peaceful and developed future.

Method

Research Design

The research design follows a quantitative approach to investigating and analysing relationships and variable effects, particularly regarding anger control and zero-violence training activities that avert violent instructional approaches from teachers (Fischer, Boone, & Neumann, 2023). The research collects data about numbers systematically to identify patterns that enable drawing conclusions for generalisation across all teachers. Using ANOVA and regression methods together in statistical analysis will test the validity of the hypothesis and find the numbers for the meaningful relationships between variables (Taherdoost, 2022). The survey relies on ANOVA to determine significant statistical differences in group means and then uses regression to forecast how training affects selected teacher behaviour outcomes. Such powerful statistical approaches ensure the study produces valuable findings about the training program's impact, which guide both educational policies and instructional methods.

Population and Sample

This research used a purposive sampling method to choose participants from a population of 120 primary school teachers working in Baucau Municipality who had attended professional training in the Instituto Catolico para a Formacao de Professores (ICFP) on anger regulation and violence-free pedagogy (Kimmons, 2022). The training records provided a list of all eligible teachers, and 40 respondents were randomly chosen through a random number process. Such teachers had been trained on anger control and non-violent instruction and teaching techniques to enhance the interaction in the classroom and to offer a safe learning environment. The size of the sample (40 teachers) was deemed sufficient to investigate the impact of the training programme on the instructional behaviours and classroom management practices of teachers in the Baucau educational setting. This particular group selection is vital for understanding the training's overall effect on education methods and learning environment security because it enables researchers to evaluate immediate and long-term educational behavioural modifications.

A sample of primary school teachers from the Baucau municipality who took the Anger Control and Zero Violence Training at ICFP Baucau was chosen on purpose to make sure that they were typical of the whole group. The 40

chosen participants are a perfect fit for the research goals because of the way their unique traits allow them to evaluate the results of the training. Higher accuracy was achieved in the analysis because the participants were teachers who had been trained, which accurately shows the characteristics of the population. The calculation of the required sample size through power analysis established statistical power, enabling examination of significant alterations or relationships present in the collected data (Kimmons, 2022). The research was more reliable because it used a method called disciplined selection. The results were valid, and all trained teachers in the municipality could use them.

Data Collection Method

The survey questionnaire features a standardised format for gathering essential data points that correspond to research targets (Ghanad, 2023). The assessment tool reached a certain group of people who had gone through training on how to control their anger and prevent violence from happening. Researchers used the research to develop survey question elements that assess the effectiveness of the educational programme in teaching teachers how to manage their classroom anger effectively. Emotional control training, stress-reduction techniques, and techniques for staying in control during tough times are all covered in the survey.

The survey looked at how the training program has helped reduce violent teaching methods in particular. The research scores teachers' understanding of peaceful disciplinary approaches as well as analyses their stance on violent behaviour in schools, along with their frequency of nonviolent methods. The main way the survey looked at teachers' thoughts and actions about controlling anger and stopping school violence was through items on a Likert scale that had options for "strongly disagree" and "strongly agree."

Validity Testing

The study requires valid and reliable measuring tools to ensure accurate and credible results. Researchers used the content validity approach to make a survey questionnaire that covers all the important parts of Zero Violence and Anger Control Training. Such an expansive method allows the instrument to properly measure the research constructs (Rusticus, 2024). A group of experts in education, psychology, and violence prevention looked into how accurate the questionnaire items were at capturing the ideas they were meant to capture and whether they were useful for teachers who are already working. Researchers measured the content validity using the scale level of content validity index, which provides a controlled way to see how experts agree on whether an item is appropriate. The thorough validation testing makes sure that the survey tool is both conceptually sound and useful in real life. This process makes the data and conclusions more reliable.

Reliability Testing

Researchers checked the instrument's dependability to make sure it measured important Anger Control and Zero Violence Training variables correctly and consistently (Kennedy, 2022). The main statistical approach for determining survey item internal consistency used Cronbach's alpha metrics, which help with the SPSS (Statistical Package for Social Science) program. This method demonstrates how measurement scales perform collectively by analysing the correlations between each item on the questionnaire. Results from Cronbach's alpha served as the primary indicator of reliability since a score above 0.70 symbolised satisfactory measurement quality. The set threshold enables the instrument to consistently gather accurate data. This process makes the research results more reliable and easier to repeat. The study can move on to analysis because the method of measurement shows the accurate evaluation of the variables being studied, which increases the validity of the research.

Regression Analysis

A method called regression analysis was used to find out how independent factors, such as Anger Control and Zero Violence Training, affect the outcomes of teachers' violent classroom behavior (Lee, 2022). The technique contains two basic procedures. To figure out how different variables affect outcomes, we used simple linear regression to find the relationship between the single independent variable and the dependent variable. A multiple regression analysis processes a simultaneous assessment of various independent factors affecting teachers' behavioural outcomes to identify comprehensive factor interactions that influence teaching behavior (Ali & Younas, 2021).

Researchers checked many important assumptions, like the linearity of variable connections, before conducting the regression analysis. Researchers used SPSS software to do F-tests (ANOVA) and R-squared and adjusted R-squared values to see how well the whole regression model could explain changes in the dependent variable. T-tests were used to see if each predictor variable was statistically significant, and regression coefficients were used to find the direction and strength of the relationship (Roni & Djajadikerta, 2021). The in-depth study gives us strong clues about what causes the number of violent school activities, which will help us make better policies and come up with better ways to help students who are being bullied.

Ethical Considerations

Before any data was collected, all participants gave their informed consent, which showed that they fully understood the study's goals and methods, as well as their rights as participants (Pietrzykowski & Smilowska, 2021). Investigators told participants in great detail about the main goals of the study, what kind of work they would be doing, and what benefits and drawbacks might come up. Participants who sign consent forms for voluntary participation make it possible to include them in the research project. Researchers used secure storage for all collected data and protected participants' privacy by using anonymous codes instead of personal information. The steps ensure the confidentiality of participants by keeping each response anonymous. The Institutional Review Board approved the ethics standards following an assessment by the relevant authority before the study's commencement. The institutional review board evaluated and verified the review process, which maintains ethical standards for protecting participant dignity and upholding beneficence and justice. Research studies become ethically possible through this method of procedural approval.

Results and Discussion

Results

Validity Test Result

The content validity test was approached at the scale-level content validity index (S-CVI). The content validity test results are shown in the following table.

Table 1. Validity Test Result

Content Validity	Validator I	Validator II	Mean (Validity score)
Anger and Emotion Control (Self-Perception and Practice)	4	4	4.00
Sharing and Collaboration	4	4	4.00
Understanding and Practicing Non-Violence in Teaching	4	3	3.50
Advocacy and School-Wide Influence	3	3	3.00
Equity and Inclusion in Teaching	3	4	3.50
Safe and Supportive Learning Environment	3	4	3.50

In the content validity test of the instrument, the two experts considered six important areas concerning anger management, non-violence, and inclusive teaching practices. The validity scores presented were mean scores ranging from 3.00 to 4.00, where a rating of 4.00 indicated excellent content alignment, which was awarded to both anger and emotion control, as well as sharing and collaboration. The section with scores of 3.50 included categories such as understanding and practicing non-violence in teaching, equity and inclusion in teaching, and creating a safe and supportive learning environment, which produced a good but slightly lower agreement among validators. In contrast, the category that received a score of 3.00 focused on advocacy and school-wide influence, also representing good agreement but at a slightly lower level. The overall mean for all the categories was 21.5, with a maximum score of 24, amounting to 89.58% of the maximum score that could be achieved. The result is a high percentage, which means that the instrument has adequate overall content validity. These findings show that the measures are mostly appropriate, relevant, and highly reliable for understanding how teachers perceive and manage emotions and behaviours.

Reliability Test Result

The reliability test results used SPSS tool shown in the following table.

Table 2. Reliability Test Result

Reliability Statistics	
Cronbach's Alpha	N of Items
0.742	36

The reliability of the questionnaire was tested by using the Cronbach's Alpha method, the value of which was calculated through SPSS software and reached 0.742 for 36 items, demonstrating acceptable internal consistency. The magnitude of this score indicates the reliable measurement of one construct by multiple items. The identification of problematic items through additional evaluation would make it possible to improve the scale's reliability model. The reliable nature of this questionnaire becomes important because it ensures the validity of gathered data. The researchers should analyse and resolve problems that affect reliability because this action produces improved quality assessment tools that provide more precise results for further research.

Regression Analysis Result of the T-test

A regression analysis measured the effects of Anger Management and Zero Violence values on the Violence Prevention in Teaching variable. The table below presents the key data.

Table 3. T-test Result

Coefficients[a]					
Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	-0.357	4.889		-0.073	0.942
Anger Management	0.186	0.149	0.145	1.247	0.220
Zero Violence	0.821	0.129	0.738	6.358	0.000
a. Dependent Variable: Violence Prevention in Teaching					

The table shows a constant value of -0.357 exists with 4.889 units of standard error. The t-value stands at -0.073, while the significance level (p-value) equals 0.942. The constant term is statistically insignificant, which suggests that the expected value of "Violence Prevention in Teaching" remains unchanged when both independent variables equal zero.

The statistical value of "Anger Management" establishes a relationship of 0.186 with an error range of 0.149 through the analysis. Statistically, the standardised coefficient (beta) equals 0.145 because it shows a positive association with the dependent variable. The results show this variable remains statistically insignificant at the frequently used significance threshold of $\alpha = 0.05$ since the t-value stands at 1.247 and the p-value reaches 0.220. Statistical tests indicate that violent management does not create meaningful changes in violence prevention practices in teaching.

The coefficient value for Zero Violence equals 0.821 with a standard error measurement of 0.129. Analysis of the standardised coefficient (Beta) shows a strong 0.738 correlation between the dependent variable and the predictor. Zero Violence" demonstrates both statistical significance in this analysis with a 6.358 t-value and a 0.000 p-value, which signifies a significant association of this variable with Violence Prevention in Teaching.

Regression analysis result of the F-test (ANOVA)

The table below of ANOVA results helps determine the total significance value for the regression model.

Table 4. F-test (ANOVA) Results

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	497.327	2	248.663	43.104	.000[b]
	Residual	213.448	37	5.769		
	Total	710.775	39			
a. Dependent Variable: Violence Prevention in Teaching						
b. Predictors: (Constant), Zero Violence, Enger Management						

The regression model successfully accounts for an important amount of variation in the dependent variable. The model regression sum of squares stands at 497.327, and it operates with two degrees of freedom (df). The value of the regression mean square is 248.663. According to the F-statistic, the value reaches 43.104, which creates a p-value of 0.000. The regression model is statistically significant because at least one of the predictors, either "Anger Management" or "Zero Violence," helps explain the differences in "Violence Prevention in Teaching." The residual sum of squares reaches 213.448 during a test with 37 degrees of freedom to produce a mean square value of 5.769. The unexplained data points from "Violence Prevention in Teaching" indicate additional factors that impact the variable.

The study demonstrates that "Anger Management" shows no relationship to violence prevention in teaching, but "Zero Violence" training remarkably enhances violence prevention outcomes. The results show that anger management, together with zero violence training, effectively reduces violent educational methods among Timor-Leste teachers, thus confirming Hypothesis 1 (H1). Therefore, the importance of zero violence training since it helps educators become more effective in classroom management and emotion control to reduce violence occurrences. Future investigations should investigate supplementary elements or training bases to enhance the results, which will improve educational practices in Timor-Leste.

The regression result shows that the overall model is statistically significant (F = 43.104, p < 0.001), which shows that the predictors have a significant amount of variance in explaining violence prevention in teaching. Although in the case of anger management there is a positive but statistically insignificant impact (b = 0.145, p = 0.220), in zero violence the relationship appears to be strong and significant (b = 0.738, p < 0.001). Such results indicate that zero violence training has significant positive effects on the capacity of teachers to reduce violence in the classroom, but anger management training does not have significant effects. The findings highlight the importance of organised violence prevention programs for enhancing learning processes.

Discussion

The research results highlight the effectiveness of anger control and zero-violence training programs, which fight violent teaching practices among Timorese primary school teachers. Research data showed that anger management training produced no statistically meaningful effect on the elimination of violence in classrooms, yet zero violence training demonstrated a significant ability to strengthen non-violent teaching behaviours.

Anger management training did not significantly reduce violence, just like studies that show personal emotional control programs don't work well in environments that accept violent punishment methods (Wangdi and Namgyel, 2022; Singh and Kaur, 2023). The traditional acceptance of corporal punishment in Timor-Leste affects the effectiveness of individual-focused efforts because such approaches do not challenge the cultural defence of physical disciplinary methods (UNICEF, 2017). The research indicates that personal emotional control abilities need additional systemic changes that oppose and reshape conventional norms supporting brutal disciplinary actions within educational systems.

The complete analysis of regression results demonstrates that Zero Violence training creates solutions for both individual and broader systemic problems. Zero Violence training delivers holistic educational changes through its dual impact on both providing teachers non-violent classroom tools and transforming their views about classroom leadership and student relationships. Successful international models that have proven effective, such as Brazil's "Escolas de Paz," demonstrate that network-wide educational changes require altering institutional behavioural principles (Amaral & Ramos, 2018). To create lasting violence prevention programs, they need to combine key ideas from non-violent communication, restorative justice, empathy, and teaching that focuses on rights.

This research shows that Zero Violence training creates a strong link to preventing violence because it provides teaching methods that are suitable for different cultures, going beyond just basic discipline. Through their training programs, teachers develop professional identities, which shift their identification from disciplinarian enforcers to development-oriented facilitators who show empathy for their students. Educational professionals trained in Zero Violence principles have enhanced capability to build supportive classrooms that support mental development while promoting student development, thus advancing goals of equal opportunities in education and peaceful coexistence.

Readers need to interpret the study results in light of Timor-Leste's past and present social features. Multiple sectors in Timor-Leste are shaped by psychological and cultural remnants of the nation's extensive history of colonial rule and systemic violence, including education (Shah & Quinn, 2016; Rees et al., 2022). Any school violence reduction program needs to specifically target historical and collective traumas as fundamental elements of the issue. The post-conflict environment in Timor-Leste makes zero-violence training programs with trauma-informed approaches especially effective because they facilitate reconciliation and healing processes. Education professionals serving areas of conflict need to develop competencies both in professional techniques and emotional strength as well as community well-being and institution trust repair.

The results of this research also highlight critical considerations for the design and implementation of violence prevention programmes. Zero Violence interventions need to combine experiential learning methods, reflective opportunities and continuous professional support systems that work directly within educational institutions. Inside schools, experiential teaching methods along with peer mediation exercises combined with role-playing activities help students fully understand peaceful disciplinary strategies. It is essential to provide reflective spaces for teachers because these professional environments help process their encounters with authority along with discipline and conflict management for sustained change. The absence of proper support systems enables daily classroom stress combined with established cultural disciplinary traditions to overcome well-intended classroom behavioural modifications.

The investigated study exhibited significant findings regarding how well policies match up with other systems. Teacher training initiatives need to operate under a national education reform blueprint to show their maximum results. To achieve success, teacher development initiatives need explicit policy measures that both ban corporal punishment and support child rights and positive disciplinary practices. To guarantee proper school-level policy enactment, teachers need rigorous mechanisms for monitoring and evaluation to ensure accountability. Teachers require training, empowerment, and support to battle organisational forces that would have them return to violent disciplinary practices.

A few vital constraints need proper consideration. Since the sample size of 40 teachers offers useful information about the effectiveness of the training program, it is rather limited, which might limit the capability to use the findings in other municipalities of Timor-Leste. The implementation of Zero Violence and anger management programs faces varying reception and implementation based on differences in cultural traditions, educational financing, and historical patterns between municipalities. Research should increase its scope to include diverse teacher populations throughout different regions, thus improving study validity for communities beyond the Baucau municipality.

This research used quantitative methods to show how training succeeded, but quantitative methods prevented deeper qualitative analysis of the whole picture. Future research in this field would profit from the addition of qualitative research methods that allow researchers to learn about teachers' personal experiences and their encounters with non-violent practices while gaining insight into environmental elements that influence their work. Qualitative data collection would yield important knowledge that assists training curriculum development and enables better adjustments to specific regional conditions.

The research has demonstrated the essential nature of Zero Violence training for reducing violent teacher conduct as well as creating safety-orientated educational spaces in Timor-Leste. For violence prevention policies in schools to work successfully, teachers need more than emotional learning strategies since comprehensive, system-wide, culture-sensitive strategies need to become an essential part. Policymakers, educational leaders, and teacher educators need to fully support implementing more Zero Violence training while ensuring its effective cultural integration, sustainable implementation, and continuous assessment. To create a peaceful, development-orientated, and rights-respecting educational future for Timorese children, we must fully implement systemic, relational, and pedagogical strategies.

Conclusion

This study examined the effects of anger-control and zero-violence training on violent teaching practices among the primary school teachers of Timor-Leste. The results provide evidence that Zero-Violence Training had a significant reduction in the proportion of teachers with violent disciplinary practices. However, anger-control training alone had no distinguishable impact on teachers' emotional management. This outcome implies that the sustainability of behavioural change is higher when interventions on the systemic and classroom levels occur in contrast to one-on-one interventions on emotional regulation that cannot be carried out separately.

The study shows that culturally responsive, rights-based training is important in the transformation of teaching practices in post-conflict education environments. Zero-Violence Training will help to establish safe and supportive learning conditions by providing teachers with a set of practical solutions to positive classroom management and help them respect the dignity of the students, thus making learning more engaging. Anger management, in turn, does not seem to be enough on its own, unless it is a part of a set of changes to the whole school and professional support system.

This study contributes internationally to the discourse on violence-free education by demonstrating the effectiveness of comprehensive, evidence-based interventions in a setting where corporal punishment was once normalised. Policymakers, teacher training institutions, and school heads must ensure that non-violence is taught and monitored consistently and that society is aware of these issues. Such initiatives are critical for ensuring long-term changes in classroom safety and embracing the overall agenda of educational reform in Timor-Leste.

Recommendations

Based on the findings and related international applications, the following recommendations might be made: Techniques to manage non-violence within classrooms and society should be instilled as a part of pre-service and in-service teacher training programs so that the teachers are empowered with the skills and ways of implementing Zero-Violence effectively.

To maximise long-term behavioural change, anger management approaches should be part of a more expansive professional development program, which encompasses stress management, trauma-sensitive care, and teaching skills in the classroom.

The Ministry of Education should expand the Zero-Violence efforts beyond Baucau and into other municipalities, with a focus on rural schools where conventional disciplinary procedures are most established.

A national education policy should include a clear prohibition on corporal punishment, well-defined methods for monitoring teacher behaviour, and ongoing professional development and accountability processes.

Author (s) Contribution Rate
The first author contributed (Salvador Magno Ximenes) 50%, the second author (Ágata Moreira Freitas) 25%, and the third author (Crisogno Soares Freitas Pereira) 25%.

Ethical Approval
Ethical permission for this research was obtained from Instituto Católico para a Formação de Professores (ICFP), Baucau, Timor-Leste, Institutional Research Commission's Decision Number: 14; Date: 10.02.2025. All procedures involving human participants were conducted in accordance with the ethical standards of the relevant institutional and national research committees.

References

Amaral, D. E. L. & Ramos, J. F. P. (2018). Mediação de conflitos no ambiente escolar para promover a cultura de paz. *Conhecer: Debate Entre o Público e o Privado*, 8(21), 24–44. https://doi.org/10.32335/2238-0426.2018.8.21.1072

Ali, P., & Younas, A. (2021). Understanding and interpreting regression analysis. *Evidence-Based Nursing*, 24(4), 116-118. https://doi.org/10.1136/ebnurs-2021-103425

Bradshaw, C. P., Cohen, J., Espelage, D. L., & Nation, M. (2021). Addressing school safety through comprehensive school climate approaches. *School psychology review*, *50*(2-3), 221-236. https://doi.org/10.1080/2372966X.2021.1926321

Beck, M. (2024). Overview of education in Timor-Leste. In *International Handbook on Education in Southeast Asia* (pp. 1195-1213). Singapore: Springer Nature Singapore.

Baumgarten, E., Simmonds, M., & Mason-Jones, A. J. (2023). School-based interventions to reduce teacher violence against children: a systematic review. *Child abuse review*, *32*(4), e2803.

Durrant, J. E., & Ensom, R. (2012). Physical punishment of children: Lessons from 20 years of research. *Canadian Medical Association Journal, 184*(12), 1373–1377. https://doi.org/10.1503/cmaj.101314

Global Initiative to End All Corporal Punishment of Children. (2023). *Corporal punishment of children in Timor-Leste*. https://endcorporalpunishment.org/reports-on-every-state-and-territory/timor-leste/

Fischer, H. E., Boone, W. J., & Neumann, K. (2023). Quantitative research designs and approaches. In *Handbook of research on science education* (pp. 28-59). Routledge. https://doi.org/10.4324/9780367855758

Ghanad, A. (2023). An overview of quantitative research methods. *International journal of Multidisciplinary Research and Analysis*, *6*(08), 3794-3803. https://doi.org/10.47191/ijmra/v6-i8-52

Kennedy, I. (2022). Sample size determination in test-retest and Cronbach alpha reliability estimates. *British Journal of Contemporary Education*, 2(1), 17-29. https://www.doi.org/10.52589/BJCE-FY266HK9

Kimmons, R. (2022). Sampling: How should I choose a sample for my study? In R. Kimmons (Ed.), *Education Research*. EdTech Books. https://edtechbooks.org/education_research/sampling

Lee, S. W. (2022). Regression analysis for continuous independent variables in medical research: Statistical standard and guideline of Life Cycle Committee. *Life cycle*, 2. https://doi.org/10.54724/lc.2022.e3

Ministry of Education, Youth and Sports (MoEYS), Timor-Leste. (2020). *Education Sector Plan 2020–2024: Updated National Education Strategic Plan 2020–2030*. Global Partnership for Education.

Pietrzykowski, T., & Smilowska, K. (2021). The reality of informed consent: empirical studies on patient comprehension—systematic review. *Trials*, 22, 1-8. https://doi.org/10.1186/s13063-020-04969-w

Rusticus, S. (2024). Content validity. In *Encyclopedia of quality of life and well-being research* (pp. 1384-1385). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-031-17299-1_553

Rees, S., Thorpe, R., Tol, W., Fonseca, M., & Silove, D. (2015). Testing a cycle of family violence model in conflict-affected, low-income countries: A qualitative study from Timor-Leste. *Social Science & Medicine*, 130, 284-291. https://doi.org/10.1016/j.socscimed.2015.02.013

Rees, S. J., Mohsin, M., Klein, L., Steel, Z., Tol, W., Dadds, M., ... & Silove, D. (2022). The impact of maternal depressive symptoms and traumatic events on early childhood mental health in conflict-affected Timor-Leste. *BJPsych Open*, *8*(2), e51. https://doi.org/10.1192/bjo.2022.20

Roni, S. M., & Djajadikerta, H. G. (2021). *Data analysis with SPSS for survey-based research*. Springer. http://dx.doi.org/10.1007/978-981-16-0193-4

Singh, S., & Kaur, R. (2023). Effectiveness of anger management programs among school-going adolescents. *Journal of Adolescent Mental Health, 30*(2), 112-126. https://pmc.ncbi.nlm.nih.gov/articles/PMC10243415/

Saputra, W. N. E., Supriyanto, A., Rohmadheny, P. S., Astuti, B., Ayriza, Y., & Adiputra, S. (2020). The effect of negative peace in mind to aggressive behavior of students in Indonesia. *European Journal of Educational Research, 10*(1), 485–496. https://files.eric.ed.gov/fulltext/EJ1284323.pdf

Shah, R., & Quinn, M. (2016). Mind the gap: Global quality norms, national policy interpretations and local praxis in Timor-Leste. Compare: A Journal of Comparative and International Education, *46*(3), 394-413. https://doi.org/10.1080/03057925.2014.952930

Sayed, Y., & Novelli, M. (2016). The role of teachers in peacebuilding and social cohesion. *The Research Consortium on Education and Peacebuilding. Universities of Amsterdam, Sussex and Ulster*, 1-100.

Sprague, J. R., & Walker, H. M. (2021). *Safe and healthy schools: Practical prevention strategies*. Guilford Publications.

Taherdoost, H. (2022). Different types of data analysis; data analysis methods and techniques in research projects. *International Journal of Academic Research in Management*, 9(1), 1-9.

UNICEF. (2017). A Familiar Face: Violence in the lives of children and adolescents. UNICEF.

UNICEF. (2015). *Bringing new life into the classroom in Timor-Leste*. UNICEF.

Wangdi, T., & Namgyel, S. (2022). Classroom to reduce student disruptive behavior: An action research. *Mextesol Journal*, *46*(1), 1-11. https://doi.org/10.61871/mj.v46n1-16

World Health Organization. (2021). *Corporal punishment and health*. WHO.

Wild, K., Young, F., de Araujo, G., Fernandes, A., Gomes, L., Kelly, L., & Taft, A. (2022). Healthcare responses to gender-based violence in Timor-Leste: women want empathy, information and safety from an integrated support system. *Journal of Interpersonal Violence*, *37*(23-24). https://doi.org/10.1177/08862605211072156

Ximenes, S. M. (2025). Challenges and opportunities in implementing the 2014 primary education curriculum in Timor-Leste: A critical review of teacher perspectives. *International Journal of Applied and Advanced Multidisciplinary Research*, *3*(2), 143-152.

Ximenes, S. M. (2024). Influence of factors on teachers' achievement as better educators in primary schools. *Journal of Information System and Education Development*, *2*(4), 1-9.

Ximenes, S. M. (2026a). Community-Based Educational Leadership for Improving Teaching and Learning Quality in Timor-Leste Primary Schools: A Systematic Review. *ASEAN Journal of Community Service and Education*, *5*(2), 85-98.

Ximenes, S. M. (2026b). Strengthening Primary Mathematics Education in Timor-Leste: Challenges, Opportunities and Implications for Teaching Practice. *International Journal of Applied and Advanced Multidisciplinary Research*, *4*(1).

From Usefulness to Trust: How AI Shapes Learning Attitudes in Higher Education

Jeranah Jeranah | [ID] | jeranahmath@stkip.ypup.ac.id
Sekolah Tinggi Keguruan dan Ilmu Pendidikan Yayasan Pendidikan Ujung Pandang, Makassar, Indonesia
Novian Candra Kurniawan[1] | [ID] | noviancandrakurniawan@gmail.com
Sekolah Rakyat Terintegrasi 53 Pontianak, Indonesia
Asdar Ahmad | [ID] | asdar.ahmad@unm.ac.id
Universitas Negeri, Makassar, Indonesia

Abstract
This study also investigates the moderating role of artificial intelligence satisfaction and the mediation role of perceived trust in the relationship. The total sample in this study consisted of 145 respondents who were analysed using partial least squares structural equation modeling (PLS-SEM) and bootstrapping procedures with the help of the SmartPLS version 4 application. The results of the analysis show that perceived usefulness does not have a positive and significant relationship with learning attitudes. Contrarily, perceived trust and artificial intelligence satisfaction have a positive and significant relationship with learning attitudes. The next expression, perceived usefulness has a positive and significant effect on perceived trust. Then, in indirect testing, perceived trust successfully functions as a mediator in the relationship between perceived usefulness and learning attitudes, but not with artificial intelligence satisfaction which acts as a weakening factor in the relationship between perceived usefulness and learning attitudes.

Keywords: Perceived usefulness, Learning attitude, Artificial intelligence satisfaction, Perceived trust

---

[1] Corresponding Author

Introduction

The development of technology that has penetrated the education sector provides benefits in higher education. Technological advancements contribute to solving the problem of learning loss (Hazin et al., 2021), and provision of efficient learning access (Ilyas et al., 2023). For students, technology plays a role in complementing teaching that still uses traditional methods (Tan & Feng, 2023). Therefore, technology's involvement in education today is not only beneficial but also a key component in avoiding and treating learning loss. Notwithstanding its many advantages, technology in the classroom has the potential to lower learning standards. Artificial intelligence (AI)-based learning technologies can lower educational quality by 25%. (Ju, 2023), act of plagiarism and learning disability (Ivanov, 2023). More specifically, AI has a negative impact on a student's cognitive abilities, such as their inability to critically think or analyse problems that are difficult to understand (Shanmugasundaram & Tamilarasu, 2023; Tolan et al., 2021). Consequently, it is crucial for students to use AI technology in a responsible manner during the learning process. One way to achieve this is by creating positive learning environments in the classroom, such as being actively involved and collaborating with classmates.

Students' attitudes toward learning have evolved significantly in recent years. AI in education has the potential to improve students' academic achievement and, consequently, their attitude toward learning (Lee et al., 2022). Students' use of AI can influence their attitudes towards learning, which will lead to continued use of AI (Chang et al., 2022), and improve students' cognitive skills (Su, 2022). Therefore, the presence of AI in learning is an advantage for students to improve their learning attitudes. Students feel that the use of AI in learning tends to help them in learning, one of which is finding reference sources for lecture materials. Wang et al. (2023) mentioned that the perception of AI use among students can increase their participation in learning. Then, Sudaryanto et al. (2023) indicates that the perception of the use of AI is a way for students to adapt to emerging technologies. Thus, AI has succeeded in providing opportunities for students to learn, but also increases anxiety about feeling realistic and intelligent. In addition, trust in the use of AI also plays a role in building students' learning attitudes.

Students' trust in the use of AI has an influence on their intention to use it. This is formed because of the integrated learning by technology and the ability of AI to interpret their searches. Musyaffi et al. (2024) explains that the trust in AI felt by students can influence their acceptance of using AI in the classroom. Meanwhile, explanations that are easy for users to understand are an important factor in building trust in using AI (Conijn et al., 2023; Qin et al., 2020). Perceived use of AI can lead to students' intention to use AI sustainably (Chang et al., 2022). Therefore, AI is often used by students to complete the assigned college assignments. More in depth, Kurniawan et al. (2024) and Neves et al. (2024) emphasized that the use of AI on students tends to have an impact on the decline in academic integrity due to plagiarism. This is due to the low awareness of students regarding the negative impacts of using AI. Therefore, Lund et al. (2024) emphasizes the importance of collaboration between publishers, editors, reviewers, and authors to mitigate the harms of AI in higher education.

Several previous studies have provided findings on the impact of AI use in higher education. However, not many studies have used variables in this study. Lee et al. (2022) and Chang et al. (2022) gives the expression that perceived usefulness has a positive impact on learning attitude with increased learning outcomes. So that it makes their learning attitude intend to use AI sustainably. Then, perceived usefulness has a positive and significant effect on perceived trust Musyaffi et al. (2024) and AI satisfaction (Conijn et al., 2023). This is because of the easy access provided and student satisfaction with the answers given by AI. However, some researchers also convey the negative impacts of using AI on students. Excessive satisfaction and high intensity of use in learning, resulting in damage to academic integrity (Hazin et al., 2021; Ivanov, 2023; Kurniawan et al., 2024; Neves et al., 2024). The imbalance between the positive and negative impacts of AI needs to be understood holistically to ensure sustainability and ethics in its use.

Although previous reviews have looked at the impact of perceived utility on learning attitude, perceived trust, and AI satisfaction, very few studies still take these factors into account. Benefits like better learning outcomes and increased student confidence in technology are the focus of most study. Therefore, the many studies showing the negative impact of AI on learning drive us to confirm in detail. This study attempts to provide readers with an understanding through theoretical and empirical approaches. This study aims to theoretically provide scholars with a comprehensive grasp of student satisfaction and confidence in the use of AI to improve learning. This paper attempts to advise policymakers to anticipate the negative consequences of deploying AI in higher education from an empirical standpoint.

Literature Review and Hypothesis

Perceived Usefulness, Perceived Trust, Learning Attitude

The term "perceived usefulness" describes significant behavioural incentives for system use. Davis et al. (1992) explains that user happiness with a system's outcomes is a measure of user trust. Liaw (2008) shows that students' behavioral intents to use technology, including the usage of artificial intelligence (AI) in higher education, can be influenced by their perceived perception. Kurniawan et al. (2024) highlighted how students frequently use AI to enhance their learning materials. Therefore, perceived trust is the degree to which a person has faith in the usage of technology that is included into education. Kou & Sun (2024) describing how their own experiences have led them to believe that they are trustworthy and dependable, which is a type of reciprocity. As an illustration, consider pupils who feel secure using technology. Alzyoud et al. (2024) confirms that perceived trust has an effect on the acceptance of AI in educational environments. In addition,, Safitri et al. (2023) defines learning attitude as the progress of students to want to learn. Further, Şen (2013) confirm that learning attitude is an important factor in problem solving ability that has a positive impact on students' academic achievement. This is confirmed by Fann (2024) dan Li (2023) indicates that learning using AI can improve positive learning attitudes in students. Thus, the perception of use and perception of trust in the use of AI in learning can build positive attitudes in students.
H1: perceived usefulness influences learning attitude
H2: perceived usefulness influences perceived trust
H3: perceived trust influences learning attitude
H5: perceived trust provides mediation in the relationship between perceived usefulness and learning attitude

Perceived Usefulness, AI Satisfaction, Learning Attitude
Perceived utility, especially artificial intelligence, is the primary driver of technology adoption in education. Additionally, a person's opinion about the employment of technology in education is also known as perceived usefulness. Their positive attitude toward using the technology tends to rise when they complete activities quickly and receive AI-provided replies. As a measure of how satisfied people are with utilizing AI, this has helped to increase AI satisfaction. Seo et al. (2023) and Kashive et al. (2021) shows that students are adapting to technology and that their attitude toward perceived usefulness affects their drive to learn. Students who keep using AI to solve problems are likely to do so consistently. Students' opinions about the application of AI in education can therefore be enhanced by AI satisfaction. Positive and successful learning experiences are also impacted by artificial intelligence (Chen et al., 2024; Huang, 2021). Then, in order to improve the perception of AI, a proactive approach to learning can help promote student participation. Students who feel comfortable utilizing AI are also more likely to be satisfied with the new technology. Zhai et al. (2021) suggests that favourable attitudes toward learning are impacted by the use of technology in the classroom, particularly in higher education. Positive and proactive learning in the classroom is thus influenced by perceived usefulness, AI satisfaction, and learning attitude.
H4: AI satisfaction m influences terhadap learning attitude
H6: AI satisfaction moderates the relationship between perceived usefulness and learning attitude
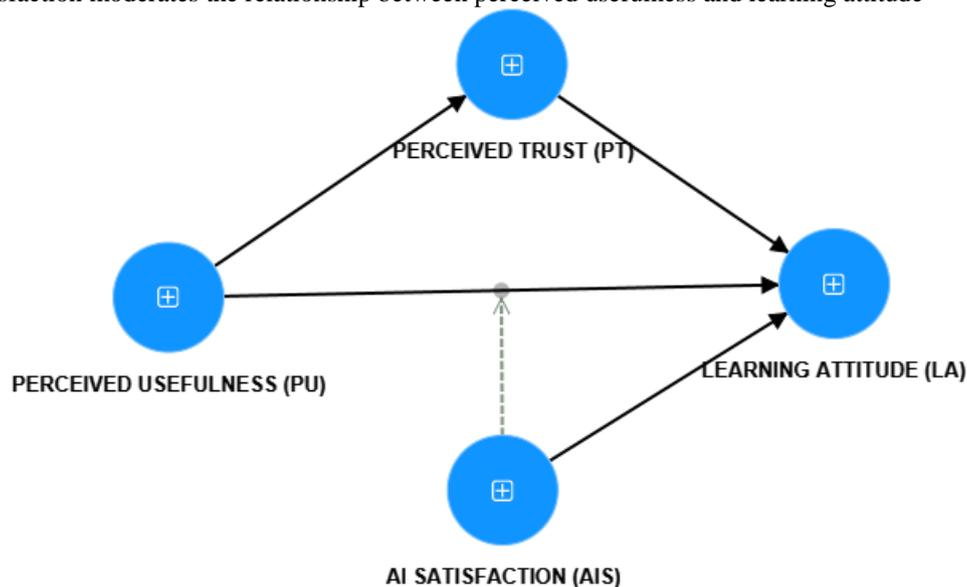

Figure 1. Conceptual framework

Materials and Methods

Research Design

An explanatory quantitative technique was used to perform the investigation. This is consistent with the study's goal of analysing the connections between all the variables. The specific goal of this study is to investigate how students' attitudes toward learning relate to how AI is perceived. Furthermore, this study seeks to explore the connection between students' perceptions of AI trust and the moderating of AI satisfaction.

Population and Sample

Students enrolled in local schools made up the research population for this study, which was carried out in South Sulawesi between September and November of 2024. An online calculator was used to determine the bare minimum of responders needed from (Soper, 2021). Four latent variables, seventeen observable variable items, an effect size of 0.3, and a probability level of 0.05 are all included in the computation. The A-priori Sample Size Calculator for Structural Equation Model indicates that 91 respondents are the bare minimum required. As a result, the study's questionnaire will be completed by at least 91 students. A Google Form-distributed online survey employing the snowball sampling technique was used to collect data. Respondent criteria include: 1) students enrolled in South Sulawesi, both at private and public universities; 2) students beginning college in 2021 and continuing until 2023; and 3) students who have employed artificial intelligence in their education at least once. In the context of cutting-edge learning, particularly regarding the application of artificial intelligence technology, these criteria were selected to guarantee that respondents possess pertinent academic expertise. According to these standards, the information gathered should provide fresh and pertinent student viewpoints on the application of technology in higher education.

Instruments and Data Procedure

A Four-point Likert scale, with 1 denoting "strongly disagree" and 4 denoting "strongly agree," was employed in this study's questionnaire to gather data from participants. Four latent variables—AI satisfaction (AIS), learning attitude (LA), perceived trust (PT), and perceived usefulness (PU)—were employed in this investigation. Every latent variable used in this investigation was taken from an existing study. Research led to the adoption of AIS. Almufarreh (2024) with a Cronbach's alpha value of 0.88, the statements "I use AI to greatly improve my ability to learn" and "For me, AI greatly facilitates and increases the effectiveness of learning" are used as instances. Next, in the LA variable, using Jia & Tu (2024) Using one instance "I am active in seeking additional information to improve my understanding of the course". Cronbach's alpha for the LA variable is 0.88. The PT variable is associated with Rahim et al. (2022) "I use AI-Chatbot if the information provided is accurate" is an example item. Cronbach's alpha for this variable is.89. Lastly, the PU variable is related to Wang et al. (2021) the example sentence "I use AI to achieve the learning objectives set" and obtain a Cronbach's alpha value of.86 instead. Table 2 displays all the test findings. After that, the data distribution results were processed with the aid of the Structural Equation Modeling (SEM-PLS) technique in the SmartPLS version 4 statistical tool. PLS-SEM is utilized in this study for data processing methods because to its dependability in generating predictions regarding the link between each variable. In the meantime, the latent variables in this study are assessed using the inner model and outer model tests. As a latent variable, the inner model test seeks to assess and perceive its reliability. The outer model test then seeks to determine the significance and impact of each previously developed hypothesis.

Results
Respondent Characteristics

The results of the questionnaire distribution show that out of the 91 determined samples, there are 145 respondents who have filled out the questionnaire with various characteristics presented in Table 1. Based on gender, there are 95 female respondents and 50 male respondents. Meanwhile, 124 respondents are under 23 years old, 11 respondents are over 29 years old, and the remaining 10 respondents are in the age range of 23 to 27 years. In addition, 125 respondents are pursuing undergraduate education, 14 respondents are pursuing diploma and doctoral education, while 6 other respondents are pursuing master's education. Lastly, regarding the intensity of AI usage among students, 83 respondents often use AI, 30 respondents very often use it, and the remaining 32 respondents rarely to very rarely use AI in their learning. Thus, the sample in this study has been fulfilled and can proceed to the testing stage.

Table 1. Profile of respondents

Characteristics	Frequency	Percentage
Gender		
Men	50	34%
Women	95	66%
Age (*years old*)		
<23	124	86%
23-25	6	4%
25-27	4	3%
>29	11	8%
Current Education		
Diploma	7	5%
Bachelors	125	86%
Magister	6	4%
Doctoral	7	5%
Year of Entrance		
2021	18	12%
2022	33	23%
2023	94	65%
Al Use Intensity		
Very Rarely	1	1%
Rarely	31	21%
Often	83	57%
Very Often	30	21%
Total	**145**	**100%**

The outer model testing aims to evaluate items up to the construct on the latent variables used in this research. The testing is conducted by evaluating outer loading, validity, and reliability. First, the outer loading test aims to evaluate the research items by examining the values of each variable. (lihat Tabel 2). A construct can be considered valid if it has a value greater than the threshold of 0.7. Secondly, the validity and reliability testing of the construct is conducted by examining the values of Cronbach's Alpha (CA), Composite Reliability (CR), and Average Variance Extracted (AVE) for each variable. Each test has a threshold that must be met: the values of CA and CR must be greater than 0.7, while AVE must be greater than 0.5. (lihat Tabel 3). Finally, the discriminant validity test aims to ensure that there is a difference between the model and the latent variables used in this study. In this study, discriminant validity is tested using cross-loading values by comparing the item values with other items horizontally. (see in Table 4).

Table 2. Outer loading value

Item	Artificial Intelligence Satisfaction (AIS)	Learning Attitude (LA)	Perceived Trust (PT)	Perceived Usefulness (PU)
1	0.87	0.80	0.82	0.89
2	0.87	0.86	0.94	0.90
3	0.81	0.80	0.87	0.85
4	0.76	0.83	0.82	
5	0.82	0.79		

Table 2 shows the outer loading values for each item in the latent variable. The results show that the AIS variable has the smallest outer loading value on item 4 (0.76 > 0.7) and the largest on items 1 and 2 with the same value, namely (0.87 > 0.7). The LA variable has the smallest outer loading on item 5 (0.79 > 0.7) and the largest on item 2 (0.86 > 0.7). Next, the PT variable has the smallest outer loading values on items 1 and 4 (0.82 > 0.7) and the highest on item 2 (0.94 > 0.7). Finally, the PU variable has the smallest outer loading value on item 3 (0.85 > 0.7) and the highest on item 2 (0.90 > 0.7). Thus, all items on the latent variables have outer loading values greater than the estimated value of 0.7. Therefore, all items have valid values, allowing for further testing. In the validity and reliability testing, the AIS variable has CA values (0.88 > 0.7), CR values (0.89 > 0.7), and AVE values (0.69 > 0.5). Next, the LA variable has CA values (0.88 > 0.7), CR values (0.88 > 0.7), and AVE values (0.67 > 0.5). The PT variable yields CA values (0.89 > 0.7), CR values (0.89 > 0.7), and AVE values (0.75 > 0.5). Finally, the PU variable has CA values (0.86 > 0.7), CR values (0.86 > 0.7), and AVE values (0.78 > 0.5). All the latent variables

used in this study have exceeded the specified thresholds, thus it can be concluded that these variables have good validity and reliability. (lihat tabel 3).

Table 3. Validity and reliability value

Variabel	CA	CR	AVE
Artificial Intelligence Satisfaction (AIS)	0.88	0.89	0.69
Learning Attitude (LA)	0.88	0.88	0.67
Perceived Trust (PT)	0.89	0.89	0.75
Perceived Usefulness (PU)	0.86	0.86	0.78

Cross-loading testing is intended to test the discriminant validate of all latent variables (AIS, LA, PT, and PU) presented in Table 4. The results of the discriminant validate test in this study indicate that all items in the construct have a greater value compared to the values around them. Thus, the discriminant validate test has been successfully fulfilled.

Table 4. Validity discriminant variabel

Item	Artificial Intelligence Satisfaction	Learning Attitude	Perceived Trust	Perceived Usefulness
AIS-1	**0.87**	0.63	0.58	0.69
AIS-2	**0.87**	0.49	0.44	0.70
AIS-3	**0.81**	0.54	0.51	0.56
AIS-4	**0.76**	0.46	0.47	0.64
AIS-5	**0.83**	0.53	0.49	0.81
LA-1	0.43	**0.80**	0.38	0.31
LA-2	0.51	**0.87**	0.49	0.35
LA-3	0.53	**0.81**	0.40	0.41
LA-4	0.52	**0.83**	0.48	0.43
LA-5	0.63	**0.79**	0.52	0.51
PT-1	0.46	0.44	**0.83**	0.51
PT-2	0.57	0.54	**0.95**	0.51
PT-3	0.60	0.46	**0.88**	0.48
PT-4	0.47	0.49	**0.83**	0.44
PU-1	0.77	0.43	0.49	**0.90**
PU-2	0.73	0.47	0.46	**0.91**
PU-3	0.68	0.43	0.52	**0.86**

Inner Model

After the outer loading criteria are met, the process proceeds to testing the inner model, which aims to evaluate the values and relationships among the developed hypotheses. Testing is done by looking at the T value and β value for each hypothesis. If the T value exceeds the 1.96 threshold, then the relationship is significant, and the hypothesis can be accepted. Conversely, if the T value is less than 1.96, then there is no significant relationship. (more details in Table 5).

Table 5. Direct and indirect hypothesis testing

Hipotesis	B	T Value	P Values	Effect Size	Conclusions
H1: PU → LA	0.14	1.36	0.17	0.01	H1 rejected
H2: PU → PT	0.55	6.81	0.00	0.44	H2 accepted
H3: PT → LA	0.26	2.66	0.00	0.08	H3 accepted
H4: AIS →LA	0.55	4.33	0.00	0.17	H4 accepted
H5: PU → PT → LA	0.14	2.38	0.01	0.02	H5 accepted
H6: AIS*PU → LA	-0.06	0.63	0.52	0.01	H6 rejected

NOTE: artificial intelligence satisfaction (AIS); learning attitude (LA); perceived trust (PT); perceived usefulness (PU); hypotheses (H)

The results of hypothesis testing are presented in Table 5. It was found that PU (β: 0.14; T: < 1.96) has no significant relationship with LA with a small effect size (0.01). PU (β: 0.55; T: > 1.96) has a positive and significant relationship with PT with a large effect size (0.44). PT (β: 0.25; T: > 1.96) also has a positive and significant relationship with LA with a small effect size (0.08). In addition, AIS (β: 0.55; T: > 1.96) has a positive and significant relationship with LA with a medium effect size (0.17). This study also examines the role of PT variables as mediators and AIS as moderators. The results show that PT exerts an indirect influence (β: 0.14; T: > 1.96) on

the PU to LA relationship with a low moderation effect (0.02). However, in the moderation test, it was found that AIS had a value (β: -0.06; T: < 1.96) that weakened the relationship of PU to LA and showed no significant effect (0.01).

Discussion

Perceived Usefulness, Perceived Trust, Learning Attitude

Statistical test results show that perceived usefulness does not have a positive and significant effect on learning attitude. This proves that the use of AI in the learning process lowers their learning attitude. The convenience provided by AI, provides dependence on its users so that it can reduce students' learning attitude. In addition, if students use AI to find answers or complete their assignments, it will reduce their motivation to learn. Study from Yani (2024) and Ju (2023) emphasized that the convenience offered by AI provides a dependency that has an impact on decreasing student motivation to learn. More deeply, Alasgarova & Rzayev (2024) mentioned that the utilization of AI in learning can interfere with the function of autonomy in the body, causing a lack of honesty in students. Students who are too dependent on AI lose their motivation to explore the material in depth. Morales-García et al. (2024) argue the reliance on AI has the effect of lowering students' cognitive skills, thus reducing their ability to explore the material. However, Li (2023) and Wu et al. (2024) denial that perceived ease of use of AI can promote positive learning attitudes, especially in higher education. Therefore, it is important for students to maintain a balance between AI and ethics in its use.

Then, the test results found that perceived usefulness has a positive and significant impact on perceived trust. This refers to the efficiency of using AI for students which can increase trust in the use of AI. Students who are confident in the accuracy of the answers provided by AI chatbot, tend to have high motivation in achieving their academic performance. Choung et al. (2023) opined that high trust in students in the use of AI, has a great impact in influencing the intention to use. Furthermore, Sun & Zhou (2024) emphasizes that the use of generative AI such as Chat-GPT, perplexity, humanta AI and so on, is able to improve students' academic quality and encourage independent learning attitudes. The contribution made by AI in learning greatly helps students to learn more efficiently by getting accurate answers from generative AI. In line with this, Ahmed et al. (2024) confirms that Generative AI offers better opportunities in learning with the personalization of learning. Thus, the utilization of AI in learning is not only about the use, but also the trust to use the technology.

Furthermore, the results of testing the outer model also show that PT has a positive and significant effect on LA. The positive effect is formed by students' trust in the use of AI as a learning resource that can be trusted and avoid plagiarism. The use of AI in learning is strongly related to the quality of information sources obtained. Prokhorova et al. (2024) confirmed if students feel satisfaction in using AI to find information about lecture material quickly. Similarly, Ahmed et al. (2024) argued that AI plays a positive role in building learning attitudes by providing a more interactive and motivating experience. Moreover, the results of generative AI writing that match students' expectations have an impact on motivation to explore the material in more depth. Therefore, AI can build a proactive learning attitude in understanding and applying the material. Leong et al. (2024) and Davis et al. (1992) opined that the use can help students to find the material they want by using AI-based instruction. Thus, the use of AI in learning is very effective in fostering students' learning attitude, especially their engagement in classroom learning. This is related to the understanding of the material being studied.

PT successfully moderates the relationship between PU and LA. The positive impact of PU on PT increases students' trust in AI through the efficiency and accuracy of the answers provided. This student trust strengthens the relationship with more positive learning attitudes. PT also shapes students' perceptions of AI as a learning resource that is trustworthy and safe from plagiarism. This trust encourages students to explore the material more deeply and understand the broader context. Overall, PT strengthens the effectiveness of AI use in fostering proactive learning attitudes, increasing engagement in learning, and promoting better learning outcomes. In line with this, Ralhan (2024) and Oseremi Onesi-Ozigagun et al. (2024) supports that the integration of responsible and unethical use of AI will encourage students to avoid plagiarism in higher education. Furthermore, Amoozadeh et al. (2024) mentioned that students' trust in the use of AI in learning is able to build their engagement in the learning process. In addition, Leong et al. (2024) dan Ahmed et al. (2024) gave the opinion that the proactive attitude of students cannot be separated from the role of AI to provide personalization in learning.

Perceived Usefulness, AI Satisfaction, Learning Attitude

The positive relationship of AIS to LA was established by the benefits that students perceived in using AI for learning. This finding confirms that AI is successful in building positive learning attitudes. Students feel that the use of AI in learning, makes it easier for them to prepare content, materials, improve learning abilities, and valuable

benefits from the use of AI. Students' use of AI encourages them to create a positive learning attitude (Li, 2023; Wu et al., 2024), improve cognitive ability (Su, 2022), which has an impact on student learning outcomes (Chang et al., 2022). In addition, the use of AI on students also has an impact on the effectiveness of time in understanding the material independently. The wise use of AI in students will raise awareness about their mastery of course material. Thus, AI acts as a catalyst that can build commitment to student learning success.

Although the previous test results show that PU has a positive impact on both AIS and LA, the moderation test shows that AIS can weaken the relationship between PU and LA. This finding indicates that students who depend on the use of AI may weaken their intrinsic motivation and thus reduce their critical thinking ability. Furthermore, the ease of finding answers from AI causes students to be less motivated in exploring the material in depth. Research in line with these findings states that the excessive use of AI has an impact on the decline of critical thinking skills (Shanmugasundaram & Tamilarasu, 2023; Tolan et al., 2021), reduced students' critical thinking skills (Hazin et al., 2021; Ivanov, 2023), and the destruction of academic integrity such as plagiarism (Ivanov, 2023; Kurniawan et al., 2024). Therefore, while AI can help students with their work, it is important to be aware of its negative impact on their cognitive and psychomotor abilities.

The findings presented earlier contradict some previous studies. Kurniawan et al. (2024) dan Neves et al. (2024) argues that the high intensity of AI use will lead to a decline in academic integrity such as plagiarism. Then, Ivanov (2023) explained that the high use of AI has an impact on the decline in students' cognitive abilities. Therefore, Husna et al. (2024) emphasizes the need for self-control in the use of AI as an effort to avoid the adverse effects of its use. In terms of self-determination theory (SDT), which explains that lecturer support and student expertise in the use of AI play an important role in encouraging students' intrinsic motivation and independent learning (Chiu et al., 2023; Zhou & Zhang, 2024). In depth, SDT lends support to these findings with the question that internal motivation plays a key role in students' satisfaction with AI use.

Conclusions

This study highlights the impact of AI use among university students in Indonesia, particularly in South Sulawesi. The author provides valuable insights for researchers by examining the relationship between the variables of perceived usefulness, AI satisfaction, perceived trust, and learning attitude. The results of this study emphasize the importance of maintaining a balance in the use of AI in learning. Although AI offers convenience to its users, dependence on AI may decrease intrinsic motivation and critical thinking ability. Self-control in AI use is very important for students to avoid negative impacts on academic integrity. The practical implication for teachers in higher education is the importance of building ethical use of AI among students, for example by including ethical use of AI curriculum in the learning process. This is needed as a preventive measure to avoid the negative impact of AI for students. The implementation of this study has limitations in the variables studied and the number of samples used. A sample limited to students in South Sulawesi may limit the generalization of findings to students in other regions. In addition, this study is also limited to the variables used. Therefore, future research can expand the scope of the study area and consider other factors that may affect students' motivation in using AI in learning.

References

Ahmed, Z., Shanto, S. S., Rime, Most. H. K., Morol, Md. K., Fahad, N., Hossen, Md. J., & Abdullah‑Al‑Jubair, Md. (2024). The Generative AI Landscape in Education: Mapping the Terrain of Opportunities, Challenges, and Student Perception. *IEEE Access*, *12*, 147023–147050. https://doi.org/10.1109/ACCESS.2024.3461874

Alasgarova, R., & Rzayev, J. (2024). The Role of Artificial Intelligence in Shaping High School Students' Motivation. *International Journal of Technology in Education and Science*. https://doi.org/10.46328/ijtes.553

Almufarreh, A. (2024). Determinants of Students' Satisfaction with AI Tools in Education: A PLS-SEM-ANN Approach. *Sustainability*, *16*(13), 5354. https://doi.org/10.3390/su16135354

Alzyoud, M., Al-Shanableh, N., Alomar, S., AsadAlnaser, A., Mustafad, A., Al-Momani, A., & Al-Hawary, S. (2024). Artificial intelligence in Jordanian education: Assessing acceptance via perceived cybersecurity, novelty value, and perceived trust. *International Journal of Data and Network Science*, *8*(2), 823–834.

Amoozadeh, M., Daniels, D., Nam, D., Kumar, A., Chen, S., Hilton, M., Srinivasa Ragavan, S., & Alipour, M. A. (2024). Trust in Generative AI among Students: An exploratory study. *Proceedings of the 55th ACM Technical Symposium on Computer Science Education V. 1*, 67–73. https://doi.org/10.1145/3626252.3630842

Chang, Y., Lee, S., Wong, S. F., & Jeong, S. (2022). AI-powered learning application use and gratification: an integrative model. *Information Technology & People*, *35*(7), 2115–2139. https://doi.org/10.1108/ITP-09-2020-0632

Chen, S. Y., Su, Y. S., Ku, Y. Y., Lai, C. F., & Hsiao, K. L. (2024). Exploring the factors of students' intention to participate in AI software development. *Library Hi Tech*, *42*(2). https://doi.org/10.1108/LHT-12-2021-0480

Chiu, T. K. F., Moorhouse, B. L., Chai, C. S., & Ismailov, M. (2023). Teacher support and student motivation to learn with Artificial Intelligence (AI) based chatbot. *Interactive Learning Environments*, 1–17. https://doi.org/10.1080/10494820.2023.2172044

Choung, H., David, P., & Ross, A. (2023). Trust in AI and Its Role in the Acceptance of AI Technologies. *International Journal of Human–Computer Interaction*, *39*(9), 1727–1739. https://doi.org/10.1080/10447318.2022.2050543

Conijn, R., Kahr, P., & Snijders, C. (2023). The Effects of Explanations in Automated Essay Scoring Systems on Student Trust and Motivation. *Journal of Learning Analytics*, *10*(1), 37–53. https://doi.org/10.18608/jla.2023.7801

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1992). Extrinsic and intrinsic motivation to use computers in the workplace. *Journal of Applied Social Psychology*, *22*(14), 1111–1132.

Fann, S.-C. (2024). A Preliminary Study on Generative AI Drawing Systems in Design Courses: A Case Study of Introduction to Design. *International Conference on Kansei Engineering & Emotion Research*, 14–27.

Hazin, M., Hidayat, S., Tanjung, A. S., Syamwiel, A., & Hakim, A. (2021). Pendampingan psikososial dan modul pembelajaran sekolah dasar untuk mengatasi learning loss. *Jubaedah: Jurnal Pengabdian Dan Edukasi Sekolah (Indonesian Journal of Community Services and School Education)*, *1*(2), 178–189.

Huang, C. H. (2021). Using pls-sem model to explore the influencing factors of learning satisfaction in blended learning. *Education Sciences*, *11*(5). https://doi.org/10.3390/educsci11050249

Husna, R., Ramadhani, S., & A'yun, Q. (2024). The Role of Self-Control in Overcoming Ethical Challenges in the Development of Artificial Intelligence. *BICC Proceedings*, *2*, 165–169. https://doi.org/10.30983/bicc.v1i1.123

Ilyas, A., Akbar, S. S., Hamza Wajid, S., Joghee, S., Fatima, A., & Mago, B. (2023). The Growing Importance of Modern Technology in Education. *2023 International Conference on Business Analytics for Technology and Security (ICBATS)*, 1–4. https://doi.org/10.1109/ICBATS57792.2023.10111128

Ivanov, S. (2023). The dark side of artificial intelligence in higher education. *The Service Industries Journal*, *43*(15–16), 1055–1082. https://doi.org/10.1080/02642069.2023.2258799

Jia, X.-H., & Tu, J.-C. (2024). Towards a New Conceptual Model of AI-Enhanced Learning for College Students: The Roles of Artificial Intelligence Capabilities, General Self-Efficacy, Learning Motivation, and Critical Thinking Awareness. *Systems*, *12*(3), 74. https://doi.org/10.3390/systems12030074

Ju, Q. (2023). Experimental Evidence on Negative Impact of Generative AI on Scientific Learning Outcomes. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.4567696

Kashive, N., Powale, L., & Kashive, K. (2021). Understanding user perception toward artificial intelligence (AI) enabled e-learning. *International Journal of Information and Learning Technology*, *38*(1). https://doi.org/10.1108/IJILT-05-2020-0090

Kou, L., & Sun, X. (2024). The Influence of Perceived Trust, Perceived Value, Perceived Usefulness, and Perceived Risk on College Students' Initial Willingness to Pay for Online Knowledge. *Creative Business and Sustainability Journal*, *46*(1).

Kurniawan, N. C., Kurnia, M., & Fadilah, M. A. (2024). Actions of Plagiarism in Students: the Role of Self-Efficacy, Learning Motivation, and Artificial Intelligence in Learning. *Proceeding International Conference on Religion, Science and Education*, *3*, 357–365. https://sunankalijaga.org/prosiding/index.php/icrse/article/view/1256

Lee, Y.-F., Hwang, G.-J., & Chen, P.-Y. (2022). Impacts of an AI-based cha bot on college students' after-class review, academic performance, self-efficacy, learning attitude, and motivation. *Educational Technology Research and Development*, *70*(5), 1843–1865.

Leong, J., Pataranutaporn, P., Danry, V., Perteneder, F., Mao, Y., & Maes, P. (2024). Putting Things into Context: Generative AI-Enabled Context Personalization for Vocabulary Learning Improves Learning Motivation. *Proceedings of the CHI Conference on Human Factors in Computing Systems*, 1–15. https://doi.org/10.1145/3613904.3642393

Li, K. (2023). Determinants of college students' actual use of AI-based systems: An extension of the technology acceptance model. *Sustainability*, *15*(6), 5221.

Liaw, S.-S. (2008). Investigating students' perceived satisfaction, behavioral intention, and effectiveness of e-learning: A case study of the Blackboard system. *Computers & Education*, *51*(2), 864–873. https://doi.org/10.1016/j.compedu.2007.09.005

Lund, B., Lamba, M., & Oh, S. H. (2024). The Impact of AI on Academic Research and Publishing. *ArXiv Preprint ArXiv:2406.06009*.

Morales-García, W., Sairitupa-Sanchez, L., Morales-García, S., & Morales-García, M. (2024). Development and validation of a scale for dependence on artificial intelligence in university students. *Frontiers in Education*. https://doi.org/10.3389/feduc.2024.1323898

Musyaffi, A. M., Baxtishodovich, B. S., Afriadi, B., Hafeez, M., Adha, M. A., & Wibowo, S. N. (2024). New Challenges of Learning Accounting With Artificial Intelligence: The Role of Innovation and Trust in Technology. *European Journal of Educational Research*, *volume-13-2024*(volume-13-issue-1-january-2024), 183–195. https://doi.org/10.12973/eu-jer.13.1.183

Neves, J. R., Oliveira, S. M. de, Oliveira, M. T., Neves, A. E. V., & Torsoni, G. B. (2024). Technological innovations in education: a scoping review on the impact of AI on academic integrity. *OBSERVATÓRIO DE LA ECONOMÍA LATINOAMERICANA*, *22*(7), e5803. https://doi.org/10.55905/oelv22n7-153

Oseremi Onesi-Ozigagun, Yinka James Ololade, Nsisong Louis Eyo-Udo, & Damilola Oluwaseun Ogundipe. (2024). REVOLUTIONIZING EDUCATION THROUGH AI: A COMPREHENSIVE REVIEW OF ENHANCING LEARNING EXPERIENCES. *International Journal of Applied Research in Social Sciences*, *6*(4), 589–607. https://doi.org/10.51594/ijarss.v6i4.1011

Prokhorova, Y., Gujrati, R., & Uygun, H. (2024). The use of AI Chatbots in higher education: the problem of plagiarism. *Review of Artificial Intelligence in Education*, *5*, e031. https://doi.org/10.37497/rev.artif.intell.educ.v5i00.31

Qin, F., Li, K., & Yan, J. (2020). Understanding user trust in artificial intelligence-based educational systems: Evidence from China. *British Journal of Educational Technology*, *51*(5), 1693–1710. https://doi.org/10.1111/bjet.12994

Rahim, N. I. M., A. Iahad, N., Yusof, A. F., & A. Al-Sharafi, M. (2022). AI-Based Chatbots Adoption Model for Higher-Education Institutions: A Hybrid PLS-SEM-Neural Network Modelling Approach. *Sustainability*, *14*(19), 12726. https://doi.org/10.3390/su141912726

Ralhan, P. (2024). Artificial Intelligence In Higher Studies: Use Of AI-Based Tools by University Students and its Challenges. *International Journal of Advanced Research*, *12*(09), 1282–1285. https://doi.org/10.21474/IJAR01/19563

Safitri, N. K., Sugiyem, S., & Arviana, S. I. (2023). Analysis of student learning attitudes in cad system pattern making learning at SMKN 1 Wonosari. *Jurnal Pendidikan Teknologi Dan Kejuruan*. https://doi.org/10.21831/jptk.v29i2.58546

Şen, H. (2013). The attitudes of university students towards learning. *International Journal of Approximate Reasoning*, *5*, 338–342. https://doi.org/10.7813/2075-4124.2013/5-4/B.50

Seo, H., Kwon, H., & Joe, Y. (2023). A Case Study and Effectiveness of Class with AI for Pre-service Teachers. *The Korean Society of Culture and Convergence*. https://doi.org/10.33645/cnc.2023.12.45.12.845

Shanmugasundaram, M., & Tamilarasu, A. (2023). The impact of digital technology, social media, and artificial intelligence on cognitive functions: a review. *Frontiers in Cognition*, *2*. https://doi.org/10.3389/fcogn.2023.1203077

Soper, D. (2021). A-priori sample size calculator for structural equation models [Software]. In *URL: https://www. danielsoper. com/statcalc [accessed 2023-05-25]*.

Su, K.-D. (2022). Implementation of Innovative Artificial Intelligence Cognitions with Problem-Based Learning Guided Tasks to Enhance Students' Performance in Science. *Journal of Baltic Science Education*, *21*(2), 245–257. https://doi.org/10.33225/jbse/22.21.245

Sudaryanto, M. R., Hendrawan, M. A., & Andrian, T. (2023). The Effect of Technology Readiness, Digital Competence, Perceived Usefulness, and Ease of Use on Accounting Students Artificial Intelligence Technology Adoption. *E3S Web of Conferences*, *388*, 04055. https://doi.org/10.1051/e3sconf/202338804055

Sun, L., & Zhou, L. (2024). Does Generative Artificial Intelligence Improve the Academic Achievement of College Students? A Meta-Analysis. *Journal of Educational Computing Research*, *62*(7), 1896–1933. https://doi.org/10.1177/07356331241277937

Tan, X., & Feng, H. (2023). On the Importance and Necessity of Implementing Modern Educational Technology in Applied Curriculum of Higher Vocational Colleges. *Transactions on Social Science, Education and Humanities Research*, *3*, 67–74. https://doi.org/10.62051/x2dt7n65

Tolan, S., Pesole, A., Martínez-Plumed, F., Fernández-Macías, E., Hernández-Orallo, J., & Gómez, E. (2021). Measuring the Occupational Impact of AI: Tasks, Cognitive Abilities and AI Benchmarks. *Journal of Artificial Intelligence Research*, *71*, 191–236. https://doi.org/10.1613/jair.1.12647

Wang, S., Shi, G., Lu, M., Lin, R., & Yang, J. (2021). Determinants of Active Online Learning in the Smart Learning Environment: An Empirical Study with PLS-SEM. *Sustainability*, *13*(17), 9923. https://doi.org/10.3390/su13179923

Wang, S., Wang, H., Jiang, Y., Li, P., & Yang, W. (2023). Understanding students' participation of intelligent teaching: an empirical study considering artificial intelligence usefulness, interactive reward, satisfaction, university support and enjoyment. *Interactive Learning Environments*, *31*(9), 5633–5649. https://doi.org/10.1080/10494820.2021.2012813

Wu, H., Wang, Y., & Wang, Y. (2024). "To Use or Not to Use?" A Mixed-Methods Study on the Determinants of EFL College Learners' Behavioral Intention to Use AI in the Distributed Learning Context. *The International Review of Research in Open and Distributed Learning*. https://doi.org/10.19173/irrodl.v25i3.7708

Yani, A. (2024). Peran Artificial Intelligence sebagai Salah Satu Faktor dalam Menentukan Kualitas Mahasiswa di Era Society 5.0. *Journal of Education Research*, *5*(2), 1089–1096.

Zhai, X., Chu, X., Chai, C., Jong, M., Istenič, A., Spector, M., Liu, J.-B., Yuan, J., & Li, Y. (2021). A Review of Artificial Intelligence (AI) in Education from 2010 to 2020. *Complex.*, *2021*, 8812542. https://doi.org/10.1155/2021/8812542

Zhou, J., & Zhang, H. (2024). Factors Influencing University Students' Continuance Intentions towards Self-Directed Learning Using Artificial Intelligence Tools: Insights from Structural Equation Modeling and Fuzzy-Set Qualitative Comparative Analysis. *Applied Sciences*, *14*(18), 8363. https://doi.org/10.3390/app14188363