Jurnal Hurriah: Jurnal Evaluasi Pendidikan dan Penelitian
Hurriah Journal: Journal of Educational Evaluation and Research
Volume 7, No. 1 (2026) PP 73-83

Jurnal Hurriah: Jurnal Evaluasi Pendidikan dan Penelitian
Hurriah Journal: of Educational Evaluation and Research

Journal homepage: https://academicareview.com/index.php/jh
E-ISSN: 2774-8472 I P-ISSN: 2774-8480 I DOI : 10.56806

Integration of Smart Technology and Data Analytics in Vocational Technology Education: A Bibliometric Review and Curriculum Implications

Chairul Nazalul Anshar[1,2*], M Giatman[1], Nizwardi Jalinus[1], Ernawati[1], Fadhilah[1], Dedy Irfan[1], Hansi Effendi[1]
[1] Department of Doctoral Programme in Vocational Technology Education, University Negeri Padang, Indonesia.
[2] Department of Electrical Engineering, Faculty of Engineering and Planning, Ekasakti University, West Sumatera, Indonesia

ARTICLE INFO

Article history:
Received: December, 2025
Received in revised from: January, 2026
Accepted: February, 2026
Available online: March, 28, 2026

Keywords: Vocational Technology Education, Bibliometric Analysis, Smart Technology, Digital Curriculum,

ABSTRACT

This study aims to clarify contemporary advancements in the incorporation of smart technology into Vocational Technology Education (VTE) and to devise strategic implications for curriculum development. We used a bibliometric analysis and a systematic literature review to look at 128 indexed publications from the Scopus and Web of Science databases that were published between 2015 and 2024. Data were analysed using bibliometric techniques using VOS viewer for keyword network mapping, supported by thematic analysis to generate qualitative insights. The results show that there are three basic conclusions. First, there has been a big increase in the number of publications. Between 2020 and 2024, 73% of studies were published. This is because digital transformation sped up after the pandemic. Second, the discipline is naturally multidisciplinary, with Technology Education (34%), Computer Science (28%), and Engineering Education (22% being the most important areas. Third, keyword analysis finds three main groups of ideas: new ways of teaching and developing the curriculum; using new technologies like AI, IoT, digital twins, and blockchain; and meeting the needs of Industry 4.0/5.0. The report highlights the pressing necessity to recalibrate VTE courses to enhance digital literacy, technical skills, and adaptability. Some of the most important suggestions are to use simulation-based hybrid learning, add digital twin technologies, strengthen triple helix collaboration, and make a long-term plan for digital transformation in vocational education.

1. Introduction

The swift advancement of digital transformation—propelled by developments in Artificial Intelligence, Blockchain, digital twins, and intelligent automation—has profoundly altered the global industrial framework towards Industry 5.0 (Budhyani et al., 2025). In contrast to other industrial revolutions that prioritized mechanization and efficiency, Industry 5.0 highlights human–machine collaboration, resilience, and sustainability as fundamental principles(Islam, 2024). Recent studies published in prestigious journals, including Technological Forecasting and Social Change, Journal of Cleaner Production, and Computers in Industry, emphasize that the integration of cyber-physical systems and human intelligence facilitates more adaptive, personalized, and

* Corresponding author.
E-mail address: chairulnazalulanshar@gmail.com
https://doi.org/10.56806/ jh.v7i1.379

environmentally sustainable production systems(Baako & Abroampa, 2023). This paradigm shift is especially apparent in areas like smart construction, renewable energy management, electric mobility systems, and digitalized supply chains, where real-time data analytics, predictive algorithms, and interconnected platforms are transforming operational models and decision-making processes(Khaddar et al., 2025).

The combination of Building Information Modelling (BIM), Internet of Things (IoT), and digital twin technologies in the building and infrastructure sector has facilitated enhanced lifecycle management and predictive maintenance techniques(Sholikhah et al., 2025). In the energy sector, smart grids and AI-driven forecasting models improve energy efficiency and facilitate the transition to low-carbon systems(Yue et al., 2025). The emergence of electric transportation ecosystems illustrates how digital technologies support advancements in battery management, charging infrastructure, and mobility optimization(Haryadi Hasan et al., 2025). The growing dependence on data-driven systems highlights the necessity of multidisciplinary skills that integrate technical proficiency with analytical, digital, and sustainability-focused abilities(Epizitone et al., 2023).

Nevertheless, whereas technology innovation progresses swiftly, the advancement of human capital has not consistently matched this tempo(Quiñones-Gómez et al., 2025). An expanding corpus of literature, encompassing publications from the World Economic Forum and empirical research in Studies in Higher Education and Education and Training, highlights a continual skills gap between business demands and the competences generated by formal educational institutions(Demchenko et al., 2023). The disparity is especially evident in Vocational Technology Education (VTE), where courses frequently fall behind developing technological trends and inadequately include digital capabilities, problem-solving abilities, and industry-relevant practices(Monti et al., 2025). As a result, graduates may have challenges in adjusting to swiftly changing workplaces defined by automation, digital integration, and sustainability demands(Meinhold et al., 2025).

Vocational Technology Education serves a pivotal function in mitigating this difficulty by connecting technical progress with labor preparedness(Lima et al., 2025). Contemporary educational research highlights that VTE institutions are particularly equipped to provide practice-oriented, industry-aligned training that imparts both technical and transversal abilities to learners(Böttcher et al., 2024). Achieving this connection necessitates ongoing curriculum innovation, robust collaboration with industry stakeholders, and the integration of emerging technology into educational practices(Imran & Almusharraf, 2024). In the absence of such initiatives, VTE risks detaching from the realities of contemporary industrial ecosystems(Hoffman et al., 2022).

In light of these issues, experts are increasingly promoting evidence-based methodologies for curriculum building, encompassing bibliometric and systematic literature evaluations that chart the progression of research trends and technology priorities(Howard et al., 2022). Bibliometric analysis, commonly utilized in publications like Scient metrics and Research Policy, offers a comprehensive analytical framework for finding significant themes, knowledge clusters, and developing research trajectories(Dumbuya, 2024). Analyzing keywords like automation in smart buildings, machine learning, blockchain applications, predictive maintenance, and the electric vehicle economy allows for the elucidation of the intellectual framework of contemporary technological discourse and its ramifications for education and training(Owen et al., 2022).

The work seeks to thoroughly analyses global research trends concerning smart and digital technologies and to derive strategic implications for Vocational Technology Education courses(Stöckl & Struck, 2025). This study aims to guide the construction of adaptable, future-oriented learning frameworks by synthesizing findings from recent high-quality publications that incorporate digital literacy, data analytics, smart system management, and green technology competences(Habets et al., 2020). This integration is crucial for improving graduate employability and promoting innovation, sustainability, and competitiveness within the wider industrial sector(Zhang et al., 2024).

By connecting educational methods with the evolving requirements of Industry 5.0, Vocational Technology Education can re-establish itself as a pivotal force in sustainable development and technological progress. By developing talented, adaptable, and innovation-driven human resources, VTE institutions can foster an inclusive and resilient industrial ecosystem equipped to tackle the intricate issues of the digital age.

2. Methodology

2.1 Research Type and Design

This study employs a qualitative research design based on a systematic literature review, enhanced by bibliometric analysis to guarantee both depth and rigor in the exploration of the research landscape(Roulston & Choi, 2017). Data were obtained from the Scopus and Web of Science databases, concentrating on papers from 2015 to 2024 to reflect recent advancements in the field. We used VOS viewer to do the bibliometric part, which let us see and map co-authorship networks, keyword co-occurrence, and thematic clusters that show how research on smart technology integration has changed over time(Hsieh & Shannon, 2005). To enhance the analysis, qualitative content analysis was utilized to evaluate and integrate significant themes, patterns, and conceptual trends identified in the selected literature, especially those pertaining to the implementation of smart technology in Vocational Technology Education (VTE). This dual-method approach enables a holistic comprehension that integrates quantitative mapping with thorough thematic analysis. The results from both analytical strands were then combined to make recommendations based on evidence, with a focus on helping with curriculum creation and influencing policy decisions in vocational and technical education.

2.2 Data Sources

The data sources employed in this study are representative and adequately complete to fulfil the research aims. The amalgamation of Scopus and Web of Science guarantees extensive coverage of high-caliber, peer-reviewed literature, while stringent inclusion criteria and systematic screening processes augment the dataset's relevance and validity. Despite the intrinsic constraints of literature-based research, including possible publication bias, measures such as cross-database validation and transparent selection protocols enhance the dependability of the results. The study offers a commendable degree of generalizability to the worldwide Vocational Technology Education landscape, while keeping attuned to the unique circumstances of Indonesia and other developing nations.

2.3 Inclusion and Exclusion Criteria

A bibliometric analysis utilizing VOS viewer on an archive of research keywords reveals numerous predominant and interconnected themes within the current literature. The analysis emphasizes a significant emphasis on the incorporation of digital technologies and Artificial Intelligence inside contemporary industrial settings, especially in domains such as smart buildings, construction management, sustainability, and Industry 5.0 systems. The inclusion criteria were established to encompass studies focused on the utilization of advanced computational methodologies, including Machine Learning, Deep Learning, Convolutional Neural Networks, and Artificial Neural Networks, as well as facilitating technologies such as Blockchain, digital twins, and predictive maintenance. These technologies are analyzed within application domains such as construction, energy management, supply chain systems, and electric car ecosystems. The chosen literature includes essential aspects such as risk analysis, system security, and emerging innovations like substrate-integrated waveguide technologies, highlighting the broad interdisciplinary nature of digital transformation in industrial applications.

Exclusion criteria were methodically implemented to maintain analytical focus and conceptual coherence within the realm of digital transformation research. Studies were rejected if they did not explicitly examine the convergence of digital technologies with physical systems, or if they were outside the scope of Industry 4.0 and Industry 5.0 paradigms. Specifically, themes such as food waste studies that do not use sensor technologies or artificial intelligence, non-digital biometric assessments, and solely statistical investigations devoid of relevance to smart systems or automation contexts were excluded. Furthermore, studies concentrating exclusively on the economic aspects of electric vehicles—without connection to facilitating digital infrastructures such as digital twins, smart grids, or energy management systems—were also omitted. These criteria guaranteed the retention of just those research that corresponded with the technological and systemic integration fundamental to modern industrial innovation. The subsequent table delineates the specific inclusion and exclusion criteria utilized in this bibliometric analysis.:

Table 1. Literature Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Studies discussing machine learning, deep learning, artificial neural networks, convolutional neural networks in the context of industry or construction.	Studies that only discuss algorithms without application in physical systems, industry, or smart buildings.
Research on predictive maintenance, digital twins, blockchain in supply chain management, energy, or construction.	Studies on blockchain without any connection to supply chain, energy, or security in integrated systems..
Studies on smart buildings, automation, energy management with a data-based or AI approach.	Energy research without digital components, IoT, or autonomous systems.
Literature covering Industry 5.0, electric vehicles in digital ecosystems (digital twins, smart grids).	Studies of electric vehicles that only focus on economic aspects without digital technology integration.
Research on risk management, security, and systemability in integrated technology systems.	Conventional risk analysis without the use of AI, big data, or predictive modeling.
Application of VOSviewer or bibliometric methods in analyzing related themes.	Studies that do not use bibliometric, scientometric, or systematic review analysis.
Topics such as substrate-integrated waveguides for sensor or communication applications in smart systems.	Pure engineering topics without any connection to smart systems, IoT, or AI.
Hybrid cloud integration, hybrid models in project or system management.	Cloud computing studies without any connection to digital twins, construction, or supply chains.

3. Results

3.1 Publication Distribution per Year

The analysis of the temporal distribution of publications reveals a distinct and increasing trend in research concerning the integration of smart technology in Vocational Technology Education (VTE) from 2015 to 2024. Analysis of 128 papers reveals an exponential growth pattern, with a significant acceleration noted post-2019. In the initial phase (2015–2018), publication output was relatively modest, averaging 5–8 studies annually, indicative of a preliminary stage of conceptual exploration where emerging technologies like the Internet of Things and Artificial Intelligence were progressively integrated into vocational education discourse.

An important inflection point occurred in 2019, when the number of publications surged by around 120% relative to the prior year (from 8 to 18 publications). This increase corresponds with the worldwide escalation of dialogues around Industry 4.0 and the heightened institutional and regulatory focus on equipping educational systems for the requirements of the fourth industrial revolution.

The most significant growth was between 2020 and 2022, when the number of research published each year jumped to an average of 25 to 30. The COVID-19 epidemic had a big impact on this rise. It sped up the use of digital tools in schools and made research on technology-enhanced learning more important. The year 2021 was the most productive, with 32 articles. This was a sign of a shift from emergency remote teaching to more structured hybrid and blended learning approaches. There is a minor drop in the number of publications from 2023 to 2024 (26 and 22, respectively, up to mid-2024). This suggests that research is entering a maturation phase in which efforts are more focused on deepening specific issues than on broad exploratory growth. Overall, about 73% of all the publications are from the years 2020 to 2024. This shows that integrating smart technology into vocational technology education is a rapidly growing and very important area of research in the larger context of digital transformation in education.

3.2 Distribution of Research Fields

An examination of study domains underscores the robust interdisciplinary character of this subject, illustrating the intersection of pedagogy, technology, and applied engineering sectors. There are three main groups of the 128 publications that were looked at: Technology Education (34%), Computer Science (28%), and Engineering Education (22%). The Technology Education domain, with 44 articles, is the largest and focuses on teaching methods, curriculum design, and new ways to teach. This group of studies often looks at paradigms like Technological Pedagogical Content Knowledge, technology-enhanced learning environments, and how well they work in vocational settings.

The Computer Science cluster (36 articles) focuses on the technical side of integration, such as system development, Machine Learning methods, Internet of Things designs, and digital platforms. Its significant contribution suggests that the integration of smart technology in vocational education transcends mere application, necessitating specialised technical innovation and infrastructure development. The Engineering Education cluster (28 publications), on the other hand, focuses on specific implementations in fields like mechanical, electrical, and construction engineering. It often includes real-world case studies from labs or workshops.

The rest of the publications are split between Educational Management (9%), Educational Policy (4%), and Educational Psychology (3%). This shows that while technical and pedagogical aspects are still the most important, institutional, regulatory, and learner-centred views are also becoming more important for supporting the effective and long-term use of smart technologies in Vocational Technology Education.

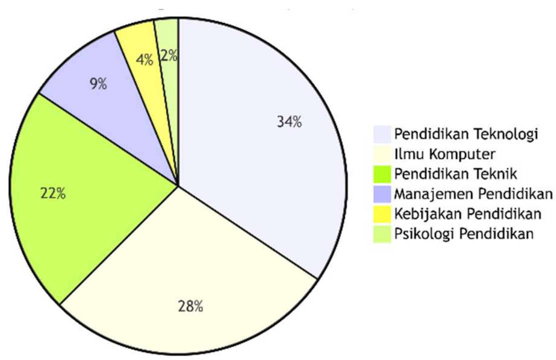

Fig 1. Distribution of Research Fields on the Integration of Smart Technology in Vocational Technology Education

A significant discovery is the elevated degree of multidisciplinary collaboration, with over 68% of papers featuring authors from a minimum of two distinct disciplines. The most significant partnership is between Technology Education and Computer Science (42 articles), followed by Engineering Education and Computer Science (31 publications). This pattern highlights the complicated nature of integrating smart technology in education, requiring a blend of pedagogical knowledge and technological skill. Frameworks like Technological Pedagogical Content Knowledge emphasise the necessity of synchronising instructional design with technological competencies. These collaborative patterns indicate that successful implementation in Vocational Technology Education relies on enduring interdisciplinary collaborations that connect teaching methodologies with technological advancements.

3.3 Keyword Analysis

An analysis of 542 keywords derived from 128 publications uncovers a complex and hierarchical conceptual framework, categorised into three principal connected groups. Co-occurrence analysis conducted with VOS viewer, utilising a minimum threshold of 10 keyword occurrences, resulted in a network of 48 nodes and 217 linkages. This network structure demonstrates the strength of relationships among essential concepts and facilitates the identification of coherent thematic clusters that define the conceptual framework of research on smart technology integration in Vocational Technology Education.

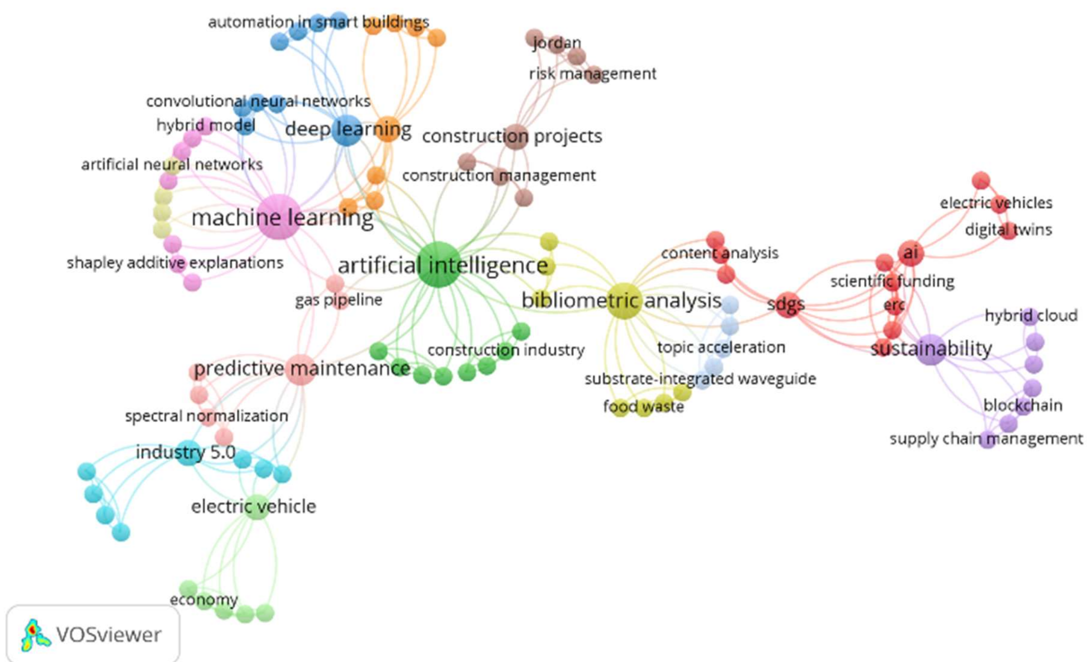

Fig. 2. Distribution of observed research fields

The keyword co-occurrence analysis uncovers a structured and multifaceted conceptual framework consisting of three primary clusters. The Red Cluster, comprising 32 keywords, constitutes the most extensive group, focused on educational technology and pedagogy. Key concepts such as vocational education, technology integration, digital skills, curriculum development, pedagogical innovation, and blended learning underscore a significant focus on instructional transformation and competency enhancement. The inclusion of concepts like 21st century skills, competency-based education, and lifelong learning emphasises the importance of adaptation and ongoing education in the digital age.

The Green Cluster (27 keywords) emphasises smart technology and technological application, featuring prominent concepts such as Artificial Intelligence, Internet of Things, Digital Twin, smart classroom, virtual reality, and Blockchain. This cluster illustrates the escalating integration of modern technology in vocational education, with rising trends like predictive analytics, adaptive learning systems, and intelligent tutoring systems, indicating a rise in personalisation and automation of learning processes.

The Blue Cluster (22 keywords) highlights the industrial context and workforce preparedness, using concepts such as Industry 4.0, workforce development, skills gap, labour market, and employability. This cluster emphasises the congruence between vocational education and industry requirements, specifically via collaboration between industry and academics, work-based learning, and apprenticeship frameworks tailored to digital transformation.

Temporal analysis reveals a distinct progression in research emphasis: initial studies (2015–2018) predominantly utilised broad terms like e-learning and ICT integration; the 2019–2021 interval introduced notions associated with Industry 4.0 and cyber-physical systems; whereas contemporary studies (2022–2024) highlight nascent themes such as the metaverse, Generative AI, sustainable technology, and human–AI collaboration. Centrality analysis shows vocational education, technological integration, and Industry 4.0 as essential bridge concepts, whilst more specialised issues like augmented reality hold marginal places within the network.

Furthermore, co-occurrence patterns demonstrate significant conceptual connections, especially between Artificial Intelligence and personalised learning, digital twins and simulation-based training, and Blockchain and credential verification, highlighting tangible applications of technology in vocational settings. These findings indicate a transition in the literature from broad discussions of educational technology to a more focused, application-driven integration of smart technologies, while emphasising pedagogical significance and curriculum development.

3.4 Discussion

This bibliometric analysis shows that research on smart technology integration in Vocational Technology Education (VTE) has changed over time. This is because technology has improved around the world and because of changes in the way industries work and the new skills that are needed for Industry 5.0. The significant rise in publications post-2019 substantiates the assertion that the COVID-19 pandemic acted as a catalyst for swift digital acceleration, necessitating vocational institutions to implement technological solutions as an operational imperative rather than a strategic option. Still, this acceleration has frequently been reactive and poorly planned, with many projects focusing on short-term technical changes instead of long-term and complete changes to the way teaching is done.

The field's strong multidisciplinary nature makes it further harder to integrate technology into VTE. The primary collaboration between technology education and computer science underscores the necessity of ongoing engagement between educators, who have contextual pedagogical knowledge, and technologists, who have experience in digital tools and platforms. Nonetheless, the somewhat restricted engagement of social sciences, public policy, and economics indicates a significant deficiency, especially in comprehending societal ramifications, formulating inclusive frameworks, and assessing the overarching effects of technological investments in educational institutions.

The discovery of three main theme clusters—digital pedagogy, smart technology, and industrial readiness—shows how VTE transformation is built on three pillars that depend on each other. Digital pedagogy stresses that technology should improve, not control, how lessons are planned. The smart technology aspect shows how important it is to use new technologies like Digital Twin and Blockchain in a way that makes sense in each situation. The industry readiness cluster, on the other hand, supports the main goal of making graduates more employable and meeting the needs of the job market. The analysis, however, shows that the conversation is not balanced, with technical issues generally taking precedence over fundamental pedagogical questions and proof of learning effectiveness.

The recent rise of advanced themes such as metaverse settings, Generative AI, and human–AI collaboration illustrates the dynamic and developing nature of this study domain. These changes make us very worried about how ready VTE institutions are, especially in poor countries like Indonesia, to not only use these new ideas but also think critically about them and put them in perspective. Ongoing obstacles, such as inadequate infrastructure, financial limitations, and deficiencies in instructors' digital skills, continue to pose substantial hurdles that are frequently overlooked in existing research.

The results indicate the necessity for strategic and systemic changes that extend beyond mere technical solutions. A detailed plan for integrating technology is needed at both the national and institutional levels. This plan should include building digital infrastructure, ongoing professional development through upskilling and reskilling, flexible curriculum design, and stronger connections with businesses. Moreover, subsequent research should emphasise local contextualisation, longitudinal impact evaluation, and sustainable finance strategies to guarantee that the digital transformation of vocational and technical education is inclusive, robust, and in harmony with the requirements of the changing industrial ecosystem.

4. Conclusions

This study, based on a bibliometric examination of 128 indexed papers from 2015 to 2024, finds that research on integrating smart technology into Vocational Technology Education (VTE) has grown rapidly, with three main themes. First, there is a noticeable exponential surge in publishing output, especially after 2019. More than 73% of research were published in the recent five years, mostly because digital transformation sped up during the COVID-19 pandemic and the conversation around Industry 4.0 and Industry 5.0 grew. Second, the subject is quite interdisciplinary, with Technology Education (34%), Computer Science (28%), and Engineering Education (22% being the most common areas of study. There is also more collaboration between professionals in teaching and technology. Third, keyword analysis shows that there is a well-developed conceptual structure with three main parts: changing the way teachers teach and developing the curriculum; using new technologies like AI, the Internet of Things, and digital twins; and meeting the needs of the job market and industry.

These results have significant ramifications for VTE advancement. Curriculum reform is necessary to integrate technical courses and to incorporate digital literacy, computational thinking, data analytics, and smart system maintenance throughout educational frameworks. Pedagogical tactics ought to evolve towards blended and hybrid models that utilize simulations, digital twins, and virtual environments to emulate real-world circumstances. Additionally, vocational schools, businesses, and technology suppliers need to work together more closely to create training systems, infrastructure, and competency requirements. Lastly, supportive policies and financing are very important for advancing research, improving teacher skills, and creating adaptive learning environments. This will make sure that VTE graduates are talented, resilient, and ready to lead in a digital and sustainable industrial landscape.

References

Baako, I., & Abroampa, W. K. (2023). Research trends on ICT integration in Education: A bibliometric analysis. *Cogent Education*, *10*(2). https://doi.org/10.1080/2331186X.2023.2281162

Böttcher, T. P., Empelmann, S., Weking, J., Hein, A., & Krcmar, H. (2024). Digital sustainable business models: Using digital technology to integrate ecological sustainability into the core of business models. *Information Systems Journal*, *34*(3), 736–761. https://doi.org/10.1111/isj.12436

Budhyani, I. D. A. M., Nitiasih, P. K., Sila, I. N., & Mahayanti, N. W. S. (2025). Bibliometric Analysis of Experiential and Technology-Integrated Pedagogy in Vocational Design Education. *Journal of Cultural Analysis and Social Change*, *10*(2), 2890–2897. https://doi.org/10.64753/jcasc.v10i2.2029

Demchenko, Y., Degeler, V., Opresu, A., & Brewer, S. (2023). Professional and 21st Century Skills for Data Driven Digital Economy. *IEEE Global Engineering Education Conference, EDUCON*, *2023-May*. https://doi.org/10.1109/EDUCON54358.2023.10125263

Dumbuya, E. (2024). *Curriculum Review: Evidence-Based Practices for Continuous Improvement*. https://doi.org/10.2139/ssrn.5018484

Epizitone, A., Moyane, S. P., & Agbehadji, I. E. (2023). A Data-Driven Paradigm for a Resilient and Sustainable Integrated Health Information Systems for Health Care Applications. *Journal of Multidisciplinary Healthcare*, *16*, 4015–4025. https://doi.org/10.2147/JMDH.S433299

Habets, O., Stoffers, J., Van der Heijden, B., & Peters, P. (2020). Am i fit for tomorrow's labor market? The effect of graduates' skills development during higher education for the 21st century's labor market. *Sustainability (Switzerland)*, *12*(18), 1799–1808. https://doi.org/10.3390/su12187746

Haryadi Hasan, D., Muhajir, A., Ilyas, M., Almuslim, U., & glumpangdua, M. (2025). Soft Skills-Based Curriculum Implementation: a Response to Educational Challenges in the Vuca and Tuna Era. *JURNAL HURRIAH: Jurnal Evaluasi Pendidikan Dan Penelitian*, *6*(2), 886–893. https://doi.org/10.56806/jh.v6i2.259

Hoffman, D. L., Moreau, C. P., Stremersch, S., & Wedel, M. (2022). The Rise of New Technologies in Marketing: A Framework and Outlook. *Journal of Marketing*, *86*(1), 1–6. https://doi.org/10.1177/00222429211061636

Howard, B., Diug, B., & Ilic, D. (2022). Methods of teaching evidence-based practice: a systematic review. *BMC Medical Education 2022 22:1*, *22*(1), 742-. https://doi.org/10.1186/s12909-022-03812-x

Hsieh, H. F., & Shannon, S. E. (2005). Three Approaches to Qualitative Content Analysis. *Qualitative Health Research*, *15*(9), 1277–1288. https://doi.org/10.1177/1049732305276687

Imran, M., & Almusharraf, N. (2024). Google Gemini as a next generation AI educational tool: a review of emerging educational technology. *Smart Learning Environments 2024 11:1*, *11*(1), 22-. https://doi.org/10.1186/s40561-024-00310-z

Islam, M. N. (2024). Mapping the landscape of smart technology in learning: a bibliometric analysis of research trends and influential factors. *International Journal of Smart Technology and Learning*, *4*(1), 48–75. https://doi.org/10.1504/ijsmarttl.2024.142177

Khaddar, A. M., Dehdi, A., Alali, A., Bakhouyi, A., & Talea, M. (2025). Emerging Technologies in Learning: A Bibliometric Analysis of Technology Integration and Applications. *International Journal of Interactive Mobile Technologies*, *19*(5), 60. https://doi.org/10.3991/ijim.v19i05.51267

Lima, F. A. F., Pimenta, M. L., Fodra, M., & Hilletofth, P. (2025). Cross-functional integration between demand and supply processes: a case study about the role of digital technologies. *Journal of Manufacturing Technology Management*, *36*(2), 553–573. https://doi.org/10.1108/JMTM-12-2023-0553

Meinhold, R., Wagner, C., & Dhar, B. K. (2025). Digital sustainability and eco-environmental sustainability: A review of emerging technologies, resource challenges, and policy implications. *Sustainable Development*, *33*(2), 2323–2338. https://doi.org/10.1002/sd.3240

Monti, T., Montagna, F., Cascini, G., & Cantamessa, M. (2025). Data-driven innovation: challenges and insights of engineering design. *Design Science*, *11*, e26. https://doi.org/10.1017/dsj.2025.10016

Owen, K. L., Watkins, R. C., & Hughes, J. C. (2022). From evidence-informed to evidence-based: An evidence building framework for education. *Review of Education*, *10*(1), e3342. https://doi.org/10.1002/rev3.3342

Quiñones-Gómez, J. C., Mor, E., & Chacón, J. (2025). Data-Driven Design in the Design Process: A Systematic Literature Review on Challenges and Opportunities. *International Journal of Human-Computer Interaction*, *41*(4), 2227–2252. https://doi.org/10.1080/10447318.2024.2318060

Roulston, K., & Choi, M. (2017). The SAGE Handbook of Qualitative Data Collection. *The SAGE Handbook of Qualitative Data Collection*, 1–736. https://books.google.ie/books?id=X0VBDwAAQBAJ

Sholikhah, R., Triyono, M. B., Sukarno, & Sudiyono. (2025). Virtual Reality-Based Learning Systems in Vocational Education and Training: A Systematic and Bibliometric Review Toward Future-Oriented Learning Environments. *2025 International Workshop on Artificial Intelligence and Education (WAIE)*, 101–105. https://doi.org/10.1109/WAIE67422.2025.11381199

Stöckl, A., & Struck, O. (2025). Continuous vocational education and training and new technologies: on the importance of educational level and technology in the workplace. *Journal for Labour Market Research 2025 59:1*, *59*(1), 12-. https://doi.org/10.1186/s12651-025-00398-x

Yue, Y., Yue, H., Wu, B., Zhou, S., Gao, J., Wei, C., Chen, Z., & Wu, Z. (2025). AI-Driven Power System Planning Under the Low-Carbon Transition. *Current Sustainable/Renewable Energy Reports 2025 12:1*, *12*(1), 27-. https://doi.org/10.1007/s40518-025-00275-8

Zhang, Y., Sun, X., & Yu, J. (2024). Transformative Technologies in the Evaluation of a Vocational Education System. *Journal of Web Engineering*, *23*(2), 275–298. https://doi.org/10.13052/jwe1540-9589.2324