

**DIGITAL PEDAGOGY IN VOCATIONAL EDUCATION: A SCOPUS-BASED  
BIBLIOMETRIC ANALYSIS (2016–2025)**

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**ABSTRAK**


Perkembangan teknologi digital telah mendorong transformasi pembelajaran pada pendidikan vokasi, namun kajian yang memetakan perkembangan penelitian digital pedagogy secara sistematis masih relatif terbatas. Penelitian ini bertujuan menganalisis tren, struktur intelektual, serta arah perkembangan riset digital pedagogy dalam konteks pendidikan vokasi melalui pendekatan bibliometrik. Data penelitian diperoleh dari database Scopus periode 2016–2025 dengan total 115 dokumen yang memenuhi kriteria inklusi. Analisis dilakukan menggunakan perangkat lunak VOSviewer dan Biblioshiny melalui tahapan analisis produktivitas publikasi, ko-sitasi, kemunculan bersama kata kunci (co-occurrence), dan jaringan kolaborasi penulis (co-authorship). Hasil penelitian menunjukkan bahwa publikasi terkait digital pedagogy dalam pendidikan vokasi mengalami pertumbuhan yang sangat signifikan dengan tingkat pertumbuhan tahunan sebesar 53,02%, yang meningkat pesat sejak pandemi COVID-19 dan terus berkembang hingga tahun 2025. Indonesia dan Finlandia tercatat sebagai negara dengan kontribusi publikasi terbesar, sedangkan Universitas Pendidikan Indonesia menjadi afiliasi yang paling produktif. Analisis visualisasi mengidentifikasi empat kluster tematik utama, yaitu integrasi kecerdasan buatan dan personalisasi pembelajaran, pembelajaran campuran dan inovasi instruksional, kompetensi digital guru vokasi, serta kesenjangan digital dan pemerataan akses pendidikan. Selain itu, evolusi tema penelitian menunjukkan pergeseran fokus dari e-learning konvensional menuju pemanfaatan teknologi imersif dan kecerdasan buatan. Temuan ini memberikan gambaran komprehensif mengenai perkembangan digital pedagogy dalam pendidikan vokasi serta menjadi dasar bagi peneliti, praktisi, dan pembuat kebijakan dalam merancang strategi pembelajaran digital yang lebih adaptif, inklusif, dan berkelanjutan.

**Kata Kunci:** *Digital Pedagogy, Pendidikan Vokasi, Analisis Bibliometrik*

**ABSTRACT**

The rapid advancement of digital technology has transformed learning practices in vocational education; however, systematic mapping of digital pedagogy research in this field remains limited. This study aims to analyze research trends, intellectual structures, and future directions of digital pedagogy in vocational education through a bibliometric approach. The data were collected from the Scopus database covering the period 2016–2025, resulting in 115 eligible documents. The analysis was conducted using VOSviewer and Biblioshiny through publication productivity analysis, co-citation analysis, keyword co-occurrence analysis, and co-authorship network analysis. The findings reveal a substantial growth in publications on digital pedagogy in vocational education, with an annual growth rate of 53.02%, accelerating during the COVID-19 pandemic

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and continuing to increase through 2025. Indonesia and Finland emerged as the leading contributors, while Universitas Pendidikan Indonesia was identified as the most productive institutional affiliation. Visualization analysis identified four major thematic clusters: artificial intelligence integration and personalized learning, blended learning and instructional innovation, vocational teachers' digital competence, and digital divide and educational equity. Furthermore, thematic evolution analysis indicates a shift from conventional e-learning toward immersive technologies and artificial intelligence applications. The study provides a comprehensive overview of the intellectual landscape of digital pedagogy in vocational education and offers valuable insights for researchers, practitioners, and policymakers in developing adaptive, inclusive, and sustainable digital learning strategies.

**Keywords:** *Digital Pedagogy, Vocational Education, Bibliometric Analisis*

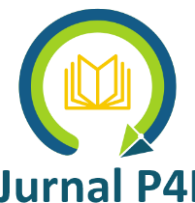
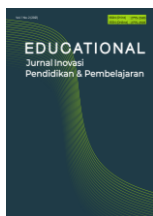
## INTRODUCTION

Vocational education has a strategic role in preparing skilled human resources who are capable of adapting to rapid industrial changes. The emergence of Industry 4.0 and Society 5.0 has transformed the competencies required in the workplace, particularly those related to digital literacy, technological proficiency, and problem-solving abilities. Consequently, vocational education institutions are expected to redesign learning systems that are more responsive to technological developments and labor market demands. One approach that has gained significant attention in recent years is digital pedagogy. According to Kämppi and Rathod (2024), digital pedagogy provides a framework for integrating digital technologies into teaching and learning processes to support the development of relevant competencies for the digital era.

Digital pedagogy is not merely associated with the use of technology in classrooms but also involves the transformation of instructional design, learning experiences, and assessment practices. Through digital pedagogy, learning can become more flexible, interactive, and learner-centered. Suárez-Guerrero et al. (2024) explain that digital pedagogy enables educators to create meaningful learning experiences through the integration of digital tools and innovative instructional strategies. Similarly, Awang et al. (2025) emphasize that technology-supported learning environments can enhance student engagement and facilitate competency development. Therefore, digital pedagogy is increasingly recognized as an essential component of educational transformation in vocational settings.

The relevance of digital pedagogy became even more evident during the COVID-19 pandemic. Educational institutions worldwide were forced to shift from conventional face-to-face learning to online and hybrid learning models within a short period. This transition accelerated the adoption of digital technologies and encouraged educators to explore innovative teaching approaches. Tolochko et al. (2025) report that the pandemic significantly increased the utilization of digital learning platforms and strengthened institutional awareness of the importance of digital readiness. As a result, digital pedagogy has evolved from an optional innovation into a fundamental requirement for contemporary education.

Vocational education possesses unique characteristics that distinguish it from general education. Its primary objective is to equip learners with practical competencies and technical skills that can be directly applied in professional environments. Consequently, the implementation of digital pedagogy in vocational education requires learning designs that extend beyond simple content delivery through digital platforms. Mazandarani and Taghaddomi (2026) argue that



vocational learning should incorporate authentic learning experiences, workplace simulations, project-based learning, and competency-based assessment. Such approaches are essential for ensuring that digital learning environments remain aligned with industry expectations and workforce requirements.

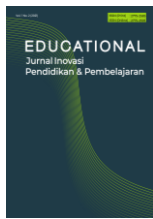
Recent technological developments have expanded the scope of digital pedagogy through the integration of artificial intelligence and advanced learning technologies. Ravipalli and Cuong (2025) introduce the Intelligent Educational Digital Pedagogy framework, which utilizes artificial intelligence and learning analytics to support personalized learning experiences. Umarova et al. (2025) demonstrate that adaptive learning technologies can improve learning effectiveness by accommodating students' diverse needs and learning preferences. Alolabi (2025) highlights the growing contribution of artificial intelligence to educational innovation and learning outcomes. Furthermore, Nhan (2025) explains that digital technologies can strengthen the alignment between vocational education and labor market demands through more responsive and data-driven instructional practices.

Despite its potential benefits, the implementation of digital pedagogy in vocational education continues to face various challenges. Kaur et al. (2026) identify limited infrastructure, inadequate professional development opportunities, and varying levels of digital competence among teachers as major barriers to successful implementation. Qin et al. (2024) further reveal that disparities in access to digital resources remain a significant issue, particularly in geographically disadvantaged areas. Hannan and Eynon (2025) emphasize that unequal access to technology may contribute to widening educational inequalities and unequal learning opportunities. These findings indicate that the ideal vision of digitally empowered vocational education has not yet been fully realized in practice.

From a research perspective, scholarly interest in digital pedagogy has increased substantially during the last decade. Kurniawan et al. (2025) note that researchers have employed various methodological approaches to investigate digital pedagogy, including literature reviews, empirical studies, and bibliometric analyses. Santoveña-Casal and López (2024) explain that bibliometric analysis is a valuable method for identifying publication trends, influential contributors, collaboration patterns, and thematic developments within a scientific field. However, Konyukhovskiy and Yakovleva (2026) argue that the conceptualization and implementation of digital pedagogy remain highly diverse across studies. Consequently, a comprehensive understanding of the intellectual structure and research evolution of digital pedagogy in vocational education is still lacking.

Based on the preceding discussion, a significant gap exists between the growing demand for digital transformation in vocational education and the limited availability of comprehensive bibliometric evidence concerning this field. Existing studies have largely focused on general educational contexts, whereas vocational education remains underrepresented in the literature. To date, there has been limited effort to comprehensively map publication growth, influential authors, institutional contributions, collaboration networks, thematic clusters, and thematic evolution within digital pedagogy research specifically related to vocational education. Therefore, this study aims to map the scientific landscape of digital pedagogy in vocational education using a bibliometric approach based on Scopus-indexed publications from 2016 to 2025. The novelty of this study lies in its integration of publication performance analysis, co-citation analysis, keyword co-occurrence mapping, and thematic evolution analysis to provide a comprehensive





understanding of the intellectual structure, research dynamics, and future directions of digital pedagogy in vocational education.

### RESEARCH METHOD

This study employed a bibliometric method to map the development of digital pedagogy research in vocational education. The data were retrieved from the Scopus database using the keywords “digital pedagogy” and “vocational education” in the title, abstract, and keyword fields combined with Boolean operators. The search was limited to publications published between 2016 and 2025 to capture research developments over the last decade. All retrieved records were exported in Scopus metadata format and screened to remove duplicate entries and irrelevant documents. A total of 115 documents that met the inclusion criteria were included in the final dataset for analysis. The data analysis consisted of descriptive and structural bibliometric analyses. Descriptive analysis was used to identify publication growth trends, leading journals, productive authors, institutions, countries, and citation performance. Structural analysis included co-citation analysis to identify the intellectual structure of the field, keyword co-occurrence analysis to map major research themes, and co-authorship analysis to examine scientific collaboration patterns. All analyses and network visualizations were conducted using VOSviewer version 1.6.20 and Biblioshiny, the web-based interface of the bibliometrix package in R. The resulting clusters and thematic networks were interpreted to provide a comprehensive overview of the research landscape and knowledge development of digital pedagogy in vocational education.

### RESULTS AND DISCUSSION

The results of the bibliometric analysis provide a comprehensive overview of the development, structure, and research trends of digital pedagogy in vocational education over the 2016–2025 period. Through descriptive and structural analyses, the study identifies publication growth patterns, leading contributors, collaboration networks, and major thematic areas that characterize the field. The findings not only reveal the current state of research but also highlight the intellectual foundations and emerging directions that shape future developments. To facilitate a systematic presentation, the results are organized into several sections covering publication performance, influential sources and contributors, geographical distribution, and thematic structures. These findings are subsequently interpreted and discussed to provide a deeper understanding of the scientific landscape of digital pedagogy in vocational education.

#### Result

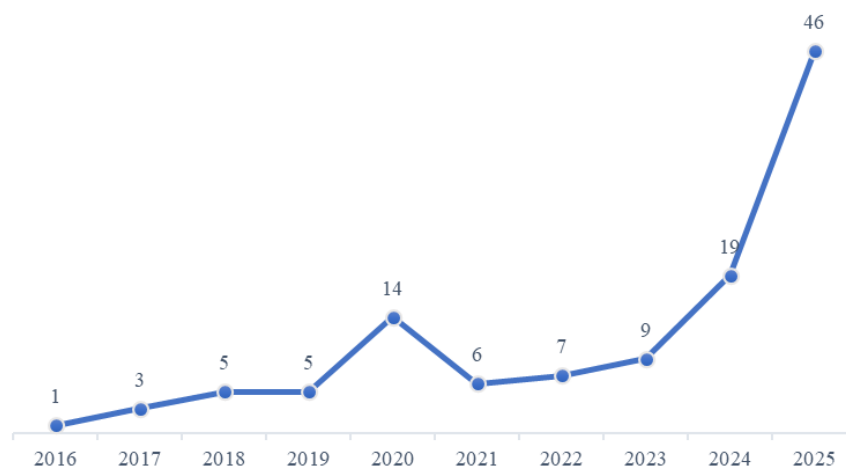
To obtain an overview of the scientific development of digital pedagogy in vocational education, a descriptive bibliometric analysis was first conducted on the retrieved dataset. The analysis focused on the characteristics of publications, authorship patterns, citation performance, and document types. The results provide a general picture of the research landscape during the 2016–2025 period. A summary of the main bibliometric information is presented in Table 1.

**Table 1. Main Information**

Description	Results
Timespan	2016–2025
Sources (Journals, Books, etc.)	92

Description	Results
Documents	115
Annual Growth Rate (%)	53.02
Document Average Age	3.17
Average Citations per Document	5.13
References	9,550
Authors	335
Authors of Single-Authored Documents	19
Single-Authored Documents	29
Co-Authors per Document	3.31
International Co-Authorships (%)	14.78

Table 1 indicates that research on digital pedagogy in vocational education has experienced substantial growth during the observation period. The field is characterized by a large number of contributing authors and publication sources, reflecting its multidisciplinary nature. Collaborative research appears to be more common than individual research, as indicated by the co-authorship pattern observed in the dataset. The citation profile also suggests that the topic has gained increasing scholarly attention in recent years. Overall, the dataset demonstrates the emergence of a dynamic and expanding research area within vocational education studies. To examine the temporal development of the field, annual scientific production was analyzed. This analysis was conducted to identify publication growth patterns and determine whether interest in digital pedagogy within vocational education has increased over time. The resulting trend is presented in Figure 1.



**Figure 1. Annual Scientific Production**

The annual publication trend shows a consistent increase in scientific output throughout the study period. During the initial years, publication activity remained relatively limited, indicating that the topic was still emerging. A more substantial increase became visible in the later years of the observation period, demonstrating growing academic interest in the integration of digital technologies within vocational education. The trend also reflects the increasing relevance of digital transformation in educational settings. By the end of the study period, publication activity had reached its highest level, confirming the continued expansion of this research domain. The productivity of publication sources was analyzed to identify journals and proceedings that have contributed most actively to the dissemination of research on digital pedagogy in vocational education. The results are presented in Table 2.

**Table 2. Most Relevant Sources**

Sources	Articles
Journal of Technical Education and Training	6
Lecture Notes in Networks and Systems	6
Obrazovanie i Nauka	6
Education and Training	4
Future-Oriented Teacher Education: Shanghai Teacher Insights 2025	3
Education Sciences	2
Journal of Engineering Science and Technology	2
Sage Open	2
10th IEEE International Conference on Cognitive Infocommunications	1
2025 13th International Conference on Orange Technology	1

The distribution of publication sources demonstrates that research on digital pedagogy in vocational education is disseminated through a variety of scholarly outlets. Several journals and conference proceedings emerged as major publication venues, indicating sustained academic interest in this topic. The presence of both educational and technology-oriented sources also reflects the interdisciplinary character of the field. Furthermore, the results suggest that vocational education research increasingly intersects with digital innovation and educational technology studies. These publication outlets collectively form the primary channels through which knowledge in this field is communicated. Author productivity was examined to identify researchers who have contributed most actively to the development of this field. The analysis considered both the number of publications and fractionalized contributions. The results are presented in Table 3.

**Table 3. Most Relevant Authors**

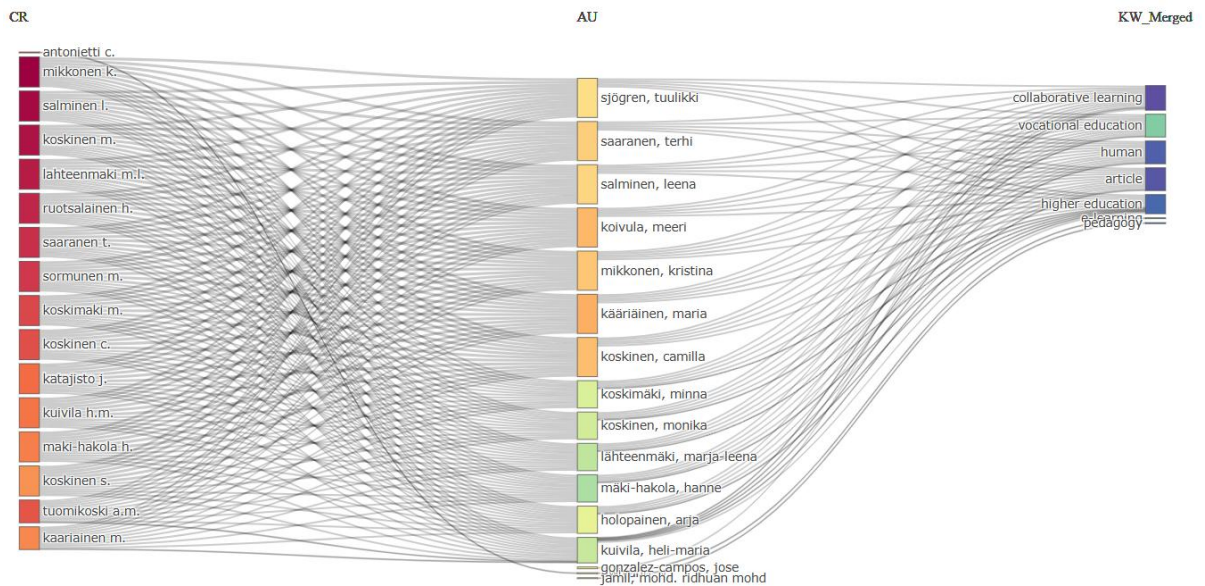
Authors	Articles	Articles Fractionalized
Koivula, Meeri	3	0.225
Koskinen, Camilla	3	0.225
Kääriäinen, Maria	3	0.225
Mikkonen, Kristina	3	0.225
Saaranen, Terhi	3	0.225
Salminen, Leena	3	0.225
Sjögren, Tuulikki	3	0.225
Ahmad, A.	2	0.400
Daniela, Linda	2	2.000
Dwiyanti, V.	2	0.400

Table 3 reveals that research productivity is concentrated among several collaborative research teams. Multiple authors contributed consistently across the study period, indicating the existence of established research groups within the field. The distribution of fractionalized contributions further illustrates differences in collaboration patterns among researchers. Some authors contributed primarily through large collaborative projects, while others demonstrated more independent publication activity. These findings highlight the importance of both collaboration and individual expertise in advancing research on digital pedagogy in vocational education. Institutional productivity was also analyzed to identify organizations that have played a major role in producing scientific publications in this field. The results are summarized in Table 4.

**Table 4. Most Relevant Affiliations**

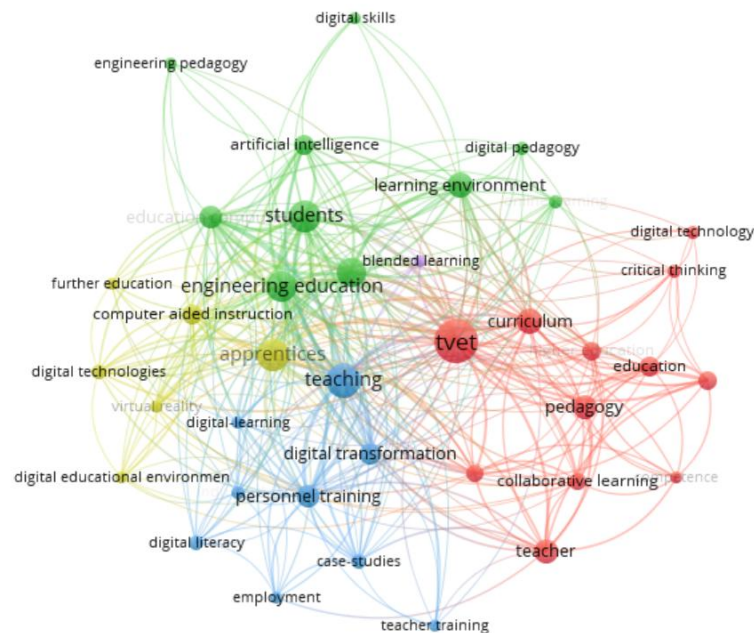
Affiliation	Articles
Universitas Pendidikan Indonesia	12
University of Oulu	11
Universitas Negeri Yogyakarta	7
Monash University	6
Queensland University of Technology	6
Tampere University of Applied Sciences	6
Zhejiang University of Technology	6
Minin Nizhny Novgorod State Pedagogical University	5
Universiti Tun Hussein Onn Malaysia	5
University of Eastern Finland	5

The affiliation analysis demonstrates that research activity is distributed across institutions from different geographical regions. Several universities contributed repeatedly to the development of the field, indicating sustained institutional engagement with digital pedagogy research. The presence of institutions from Asia, Europe, and Australia suggests a broad international interest in the topic. At the same time, the results indicate that a limited number of universities serve as major centers of research productivity. These institutions play an important role in shaping the direction and visibility of digital pedagogy research within vocational education. To understand the geographical structure of the field, country-level contributions and collaboration patterns were examined. The visualization of the most cited countries is presented in Figure 2.



**Figure 2. Most Cited Countries**

The geographical distribution of publications demonstrates that research contributions are concentrated in several countries with strong vocational education systems and active digital transformation initiatives. Citation performance varies across countries, indicating differences in research visibility and international influence. The collaboration analysis also shows that international cooperation remains relatively limited compared with domestic research activity. Nevertheless, the presence of cross-national collaborations suggests increasing global engagement in addressing issues related to digital pedagogy. These findings reveal both the strengths and the remaining opportunities for expanding international research networks in the field. The final stage of the analysis focused on identifying the intellectual structure and thematic organization of the field through network visualization and thematic mapping. This analysis revealed the major research streams that have shaped the development of digital pedagogy in vocational education. The visualization results are presented in Figure 3.



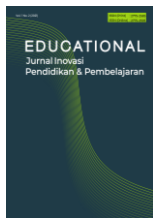
**Figure 3. VOSviewer Co-Citation Network Visualization**

The network visualization demonstrates the existence of several interconnected thematic clusters within the field. These clusters represent major areas of scholarly attention and indicate the diversity of topics examined by researchers. Despite differences in thematic focus, the clusters remain connected through shared conceptual foundations and research interests. The visualization also highlights the presence of central themes that function as important bridges between different areas of inquiry. Overall, the network structure reflects a mature and evolving body of knowledge that continues to expand in response to technological and educational developments.

## Discussions

The findings of this study indicate that digital pedagogy in vocational education has evolved into a dynamic and increasingly prominent research field. The continuous growth of publications over the last decade reflects the increasing attention of researchers to the integration of digital technologies in vocational learning environments. This trend suggests that digital transformation has become an essential component of vocational education development. The thematic clusters identified through bibliometric mapping further demonstrate that digital pedagogy is no longer viewed solely as a technological innovation but as a strategic approach to improving learning quality and workforce preparedness. This finding supports the view that digital pedagogy has become a central element in contemporary educational transformation (Bećirović, 2023).

From a conceptual perspective, the results reveal that digital pedagogy in vocational education remains multidimensional and continues to develop through the incorporation of emerging technologies. The thematic network identified several interconnected concepts related to digital learning, technological integration, and competency development. This pattern indicates that the field has expanded beyond the traditional understanding of technology-supported



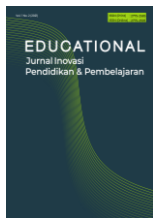
instruction. In vocational education settings, digital pedagogy increasingly emphasizes the development of workplace competencies through authentic and technology-rich learning experiences. Such findings are consistent with the argument that digital pedagogy should be positioned as an integral component of competency development rather than merely a supporting instructional tool (Jiang et al., 2024).

Another important finding concerns the growing prominence of artificial intelligence and learning analytics within the research landscape. The thematic analysis shows that AI-related topics have emerged as significant areas of scholarly attention in recent years. This trend reflects a broader shift toward personalized and data-driven learning environments within vocational education. The increasing visibility of AI in the thematic structure suggests that researchers are exploring new ways to improve instructional effectiveness and learner engagement through intelligent systems. These findings align with the Intelligent Educational Digital Pedagogy framework, which highlights the transformative role of artificial intelligence in supporting adaptive and personalized vocational learning experiences (Ravipalli & Cuong, 2025).

The methodological findings also demonstrate that research on digital pedagogy in vocational education has become increasingly sophisticated. The bibliometric mapping revealed the presence of diverse methodological traditions that contribute to the development of knowledge in this field. Earlier studies were generally characterized by exploratory and descriptive approaches, whereas more recent studies increasingly employ advanced analytical techniques and data-driven methodologies. This transition reflects the maturation of the research field and its effort to generate stronger empirical evidence. The observed methodological diversity is in line with the growing adoption of mixed-methods and evidence-based research approaches within digital education studies (Kurniawan et al., 2025).

The collaboration patterns identified in this study further indicate the emergence of an international research community focused on digital pedagogy in vocational education. The contribution of institutions from different regions demonstrates that interest in this topic is not limited to a specific geographical context. International collaboration enables the exchange of knowledge, experiences, and technological innovations that enrich the development of the field. At the same time, the relatively limited proportion of international co-authorship suggests that opportunities for broader global collaboration remain available. Strengthening international partnerships may contribute to the development of more comprehensive and globally relevant digital pedagogy models for vocational education.

From a practical perspective, the findings highlight the growing adoption of digital tools and technology-enhanced learning environments in vocational education. The thematic clusters show increasing attention to virtual simulations, adaptive learning systems, and immersive learning technologies. These innovations have the potential to support experiential learning by enabling students to engage in realistic workplace scenarios without the constraints of physical environments. The emergence of such technologies within the research landscape indicates that vocational education is progressively embracing digital solutions to strengthen competency development. Similar trends have been reported in studies examining the implementation of digital platforms and technology-enhanced learning systems in vocational contexts (Umarova et al., 2025). Research on artificial intelligence in education has also emphasized the growing contribution of intelligent technologies to improving learning effectiveness and instructional innovation (Alolabi, 2025).



Despite these positive developments, the findings also reveal several persistent challenges that continue to influence the implementation of digital pedagogy in vocational education. The thematic structure indicates ongoing concerns regarding infrastructure availability, teacher readiness, technological support, and equitable access to digital resources. These challenges suggest that the benefits of digital transformation are not yet distributed evenly across educational settings. As a result, the successful implementation of digital pedagogy requires not only technological innovation but also supportive policies and institutional commitment. Overall, the findings portray a field that is undergoing consolidation, characterized by stronger theoretical foundations and more sophisticated methodologies while still facing practical challenges related to inclusiveness, accessibility, and sustainable implementation.

## CONCLUSION

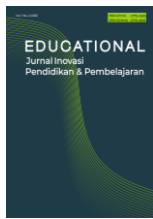
This study successfully mapped the scientific landscape of digital pedagogy in vocational education through a bibliometric analysis of Scopus-indexed publications from 2016 to 2025. The findings indicate that digital pedagogy has evolved into an increasingly established field of study, characterized by rapid publication growth, expanding international scholarly engagement, and the emergence of diverse thematic areas related to artificial intelligence, blended learning, digital competence, and educational equity. These developments demonstrate that digital pedagogy is no longer viewed merely as a technological support for instruction but has become a strategic framework for strengthening the relevance of vocational education in responding to contemporary workforce demands. The results further reveal that the field is currently undergoing a process of scientific consolidation. Conceptually, digital pedagogy in vocational education continues to develop through the integration of emerging technologies and more sophisticated learning models. Methodologically, research in this area has progressed toward more diverse and evidence-based approaches, reflecting the growing maturity of the field. Nevertheless, practical implementation remains challenged by issues related to infrastructure disparities, teacher readiness, unequal access to technology, and variations in the interpretation and application of digital pedagogy across educational contexts.

The findings of this study provide important implications for multiple stakeholders. For vocational educators, the results highlight the importance of adopting evidence-based digital learning approaches that support the development of workplace competencies. For educational institutions, the study underscores the need for sustained investment in digital infrastructure and professional development programs that strengthen teachers' digital capabilities. For policymakers, the findings emphasize the importance of designing inclusive policies that reduce digital inequalities and ensure that the benefits of educational digitalization can be accessed by all learners regardless of geographical or socioeconomic conditions. This study also contributes to the advancement of knowledge by providing a comprehensive overview of the intellectual structure, thematic evolution, and research dynamics of digital pedagogy in vocational education. The resulting knowledge map can serve as a reference for future researchers in identifying emerging themes, potential research gaps, and opportunities for interdisciplinary collaboration. Future studies are encouraged to expand data sources beyond Scopus, explore underrepresented vocational education contexts, particularly in developing countries, and conduct longitudinal investigations that examine the long-term effects of digital pedagogy on the workplace competencies and employability of vocational graduates. Such efforts are expected to support the

development of more inclusive, adaptive, and sustainable models of digital transformation in vocational education.

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