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Artificial Intelligence in Vocational Education: Trends, Contributors, and Thematic Developments

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Abstract: Artificial intelligence has become increasingly important in education, yet its development in vocational education remains underexplored. This study conducts a bibliometric analysis of 85 English language journal articles and reviews retrieved from the Web of Science Core Collection. It examines publication trends, key contributors, and thematic patterns in this field. The results show that research output was limited before 2020 but increased rapidly after 2021, reaching a peak in 2025. China was the most productive and most cited country, while citation impact across institutions, journals, and authors was uneven and often driven by a small number of highly cited studies. Keyword co-occurrence analysis identified four main thematic areas related to data-driven technologies, intelligent instructional support, learner-centered development, and future-oriented applications. These findings suggest that research on artificial intelligence in vocational education is growing rapidly, although the field has not yet developed a fully coherent intellectual and thematic structure.

1. Introduction

Artificial intelligence (AI) has emerged as a transformative force in contemporary education, driven by broader processes of digitalization, Industry 4.0, and the increasing reliance on data-driven decision-making. Over the past decade, AI technologies, including machine learning, natural language processing, and deep learning, have been progressively integrated into educational contexts, enabling new forms of personalized learning, automated assessment, and intelligent instructional support. Existing research suggests that AI is no longer simply an auxiliary tool, but is increasingly embedded in the infrastructure of educational systems, shaping how teaching, learning, and evaluation are organized [1-3].

Within this broader landscape, vocational education has become an important but comparatively underexplored area. Unlike general education, vocational education is closely aligned with labour market needs and focuses on the development of practical skills and occupational competencies. As technological change continues to reshape industries, vocational education systems are under growing pressure to adapt and prepare learners for increasingly digital and AI-supported work environments [4-6]. In this context, AI offers significant potential to enhance vocational training by supporting adaptive learning, improving instructional efficiency, and aligning educational provision with evolving skill demands.

Recent studies have demonstrated that AI can be applied in vocational education through a range of approaches, including personalized learning systems, intelligent tutoring tools, simulation-based training, and automated assessment mechanisms [7-8]. These applications may improve learning efficiency, provide real-time feedback, and support individualized instruction, particularly in practice-oriented learning environments. At the same time, emerging technologies such as generative AI and intelligent simulators are expanding the scope of vocational training by enabling more flexible, interactive, and scalable learning experiences [9-10].

Despite these developments, research on AI in vocational education remains fragmented. Existing studies are often limited to specific technologies, localized case studies, or individual application scenarios, making it difficult to obtain a comprehensive understanding of the whole field. Although some review and bibliometric studies have explored aspects of AI in education, they tend to focus on broader contexts such as higher education or online learning, with relatively limited attention to vocational settings [11-12]. As a result, there is still a lack of systematic evidence regarding the overall development trajectory, influential contributors, and thematic structure of research on AI in vocational education.

To address this gap, the present study conducts a bibliometric analysis to map the research landscape of artificial intelligence in vocational education. Specifically, the study is guided by the following research questions:

RQ1: How has research on artificial intelligence in vocational education evolved over time?

RQ2: Which countries, institutions, journals, and authors have played key roles in shaping this field?

RQ3: What are the dominant research themes, and how are they structured based on keyword co-occurrence patterns?

2. Literature Review

2.1. Artificial Intelligence in Education and Vocational Context

Artificial intelligence in education (AIED) has developed into a rapidly expanding interdisciplinary field, characterized by the integration of machine learning, natural language processing, and data-driven decision-making into educational processes. Early research focused primarily on intelligent tutoring systems and automated feedback, whereas more recent work emphasizes adaptive learning, prediction, recommendation, and automated assessment [1-3]. Bibliometric and review studies further indicate that AIED has become increasingly diversified, with strong linkages across education, computer science, and cognitive science [13-14].

At a conceptual level, AI in education is often framed in terms of its capacity to enhance personalization, efficiency, and scalability in learning systems [15]. However, the distribution of research remains uneven across educational contexts. A substantial proportion of studies focuses on higher education and general learning environments, whereas vocational education has received comparatively limited systematic attention [11]. Given its emphasis on practical competence and alignment with labour market demands, vocational education represents a distinct context in which the implications of AI extend beyond pedagogy to include workforce development and economic transformation [4-6].

2.2. Applications and Limitations of AI in Vocational Education

Existing research suggests that AI applications in vocational education can be understood along several dimensions. One important dimension concerns adaptive and personalized learning, where AI systems analyse learner data to adjust instructional content, pacing, and feedback. Such approaches are particularly relevant in vocational contexts, where learners often exhibit diverse skill levels and learning needs [7]. Empirical evidence also indicates that adaptive systems are associated with improved engagement and learning outcomes, although their effectiveness depends on contextual and pedagogical conditions [16].

Another dimension relates to instructional support and teaching practices. Technologies such as intelligent tutoring systems, automated assessment tools, and generative AI applications can assist educators in developing learning materials, designing assessments, and providing timely feedback. These tools have the potential to enhance teaching efficiency while supporting more interactive learning environments [8-9]. At the same time, existing research emphasizes that AI should complement rather than replace human instruction, as effective learning depends on the integration of technological tools with pedagogical expertise [17].

A further dimension concerns simulation-based and practice-oriented training, which is particularly significant in vocational education. AI-enabled and immersive technologies, including virtual reality, augmented reality, and intelligent simulators, create conditions for repeated practice, immediate feedback, and safe experimentation. These features are especially valuable for developing procedural and technical skills in fields such as engineering, manufacturing, and healthcare [18-19]. Beyond direct instructional use, AI is also increasingly applied to support curriculum design and institutional decision-making, for example by aligning training provision with evolving labour market needs [20]. Despite these advances, several limitations remain. Much of the existing research is based on small-scale implementations or short-term interventions, and empirical evidence often relies on self-reported perceptions rather than objective or longitudinal outcomes. In addition, challenges related to technological infrastructure, teacher readiness, and ethical concerns, such as data privacy and algorithmic bias, continue to constrain the effective integration of AI in vocational education [17].

2.3. Research Gap and Rationale for Bibliometric Analysis

Although research on AI in vocational education is growing, the field remains fragmented in terms of research focus, methodological approaches, and geographical distribution. Existing studies tend to examine specific technologies or localized applications, which limits the development of a more comprehensive understanding of the field. While review studies provide valuable thematic insights, they do not fully capture the structural development and evolution of research activity.

Bibliometric analysis provides a systematic and quantitative approach to addressing this limitation by revealing the intellectual and thematic structure of a research field [21]. In the broader AIED domain, such methods have been widely used to identify research hotspots, collaboration patterns, and emerging trends [14]. However, bibliometric research specifically focused on vocational education remains relatively limited. Accordingly, this study adopts a bibliometric approach to examine research on artificial intelligence in vocational education, with the aim of providing a clearer overview of the field and identifying directions for future research.

3. Methodology

Data were retrieved from the Web of Science Core Collection (WoSCC), which is widely used in bibliometric studies because of its rigorous indexing standards and coverage of peer-reviewed scholarly publications. The search was conducted on March 1, 2026. A topic search was performed using the following search string: TS = (“Artificial Intelligence” OR “Machine Learning” OR “Deep Learning” OR “Natural Language Processing” OR “Chat Bot” OR “Neural Network” OR “AI-based” OR “intelligent tutoring system” OR “expert system” OR “recommend* system” OR “feedback system” OR “personalized learning” OR “adaptive learning” OR “prediction system” OR “data mining” OR “prediction model” OR “automated evaluation” OR “automated assessment” OR “virtual agent” OR “intelligent support” OR “automated tutor” OR “personal tutor” OR “intelligent agent” OR “artificial agent” OR “intelligent virtual reality”)AND TS= (“vocational education” OR TVET OR “technical and vocational education” OR “vocational and technical education”). To ensure the quality and relevance of the dataset, only English-language articles and review articles published in peer-reviewed journals were included. Conference proceedings, books, non-journal publications, retracted records, and studies only marginally related to artificial intelligence in vocational education were excluded. The initial search in the Web of Science Core Collection yielded 287 records. After applying the inclusion and exclusion criteria and manually screening titles and abstracts, 85 publications were obtained for further bibliometric analysis.

4. Findings

4.1. Temporal Trends in Research Output

The temporal distribution of publications on artificial intelligence in vocational education is shown in Figure 1. Before 2020, research output was very limited, with only small number of studies published between 2011 and 2019. Publications increased noticeably after 2020 and grew rapidly from 2021, reaching a peak in 2025. These results indicate that research in this area has moved from slow early development to rapid growth in recent years.

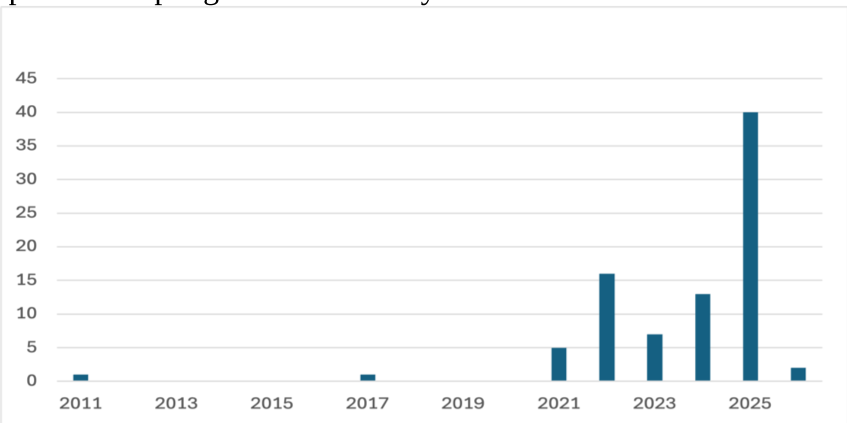

Figure 1: Annual publication output on artificial intelligence in vocational education.

4.2. Key Contributors to the Field

This section provides insights into the major contributors to research on artificial intelligence in vocational education, including countries, institutions, journals, and authors. Tables 1–4 present the top cited contributors and help identify the main sources of academic influence in this field.

As indicated in Table 1, research shows a clear geographical concentration, with Asian countries accounting for most of the top ten most cited contributors. China clearly dominated the field, recording both the highest number of publications (61) and the largest total citation count (213). Vietnam ranked second with 41 citations despite producing only two publications, suggesting that its citation visibility is driven by a small number of highly cited studies. Australia also demonstrated notable citation visibility. Malaysia, the Netherlands, and Serbia showed moderate citation presence, with 15, 14, and 10 citations, respectively. Other countries, including Pakistan, Saudi Arabia, Indonesia, and Palestine, contributed relatively smaller numbers of publications and citation counts.

Table 2 identifies the leading institutions by citation counts. Chaoyang University of Technology ranked first with 41 citations from two publications, followed by Vo Truong Toan University with 32 citations from one publication. Chongqing College of Electronic Engineering, Chongqing Industry Polytechnic College, and the University of Newcastle each recorded 29 citations based on a single publication. Northeast Normal University, Vrije Universiteit Amsterdam, and East China Normal University each contributed two publications, but their citation counts were comparatively lower. These results show that citation impact at the institutional level is not directly proportional to publication output.

Table 3 presents the top ten journals ranked by citation counts. Algorithms emerged as the most cited journal with 32 citations, followed by Journal of Organizational and End User Computing and IEEE Transactions on Learning Technologies. Notably, these journals each contributed only one publication to the dataset. By contrast, Mobile Information Systems had the highest number of publications among the listed journals, yet accumulated 17 citations, illustrating the discrepancy between publication output and citation impact.

The citation analysis also reveals an uneven authorship pattern. As shown in Table 4, Chen, Long-sheng and Thao-trang Huynh-cam received the highest citation counts, with 41 citations each from two publications. Huynh Le followed with 32 citations from a single publication. Luo, Zhilin, Ma, Xiaochun, and Shao, Xuefeng each accumulated 29 citations despite having only one publication. Authors ranked from seventh to tenth each had 19 citations from a single paper.

Table 1: Top cited countries.

Rank	Countries	No. of Publications	Citations
1	China	61	213
2	Vietnam	2	41
3	Australia	1	29
4	Malaysia	6	15
5	Netherlands	2	14
6	Serbia	2	10
7	Pakistan	1	8
8	Saudi Arabia	1	8
9	Indonesia	4	5
10	Palestine	1	4

Table 2: Top cited institutions.

Rank	Organization	No. of Publications	Citations
1	Chaoyang University of Technology	2	41
2	Vo Truong Toan University	1	32
3	Chongqing College of Electronic Engineering	1	29
4	Chongqing Industry Polytechnic College	1	29
5	University of Newcastle	1	29
6	Northeast Normal University	2	21
7	Education University of Hong Kong	1	19
8	Yellow River Conservancy Tech Institution	1	17
9	Vrije Universiteit Amsterdam	2	14
10	East China Normal University	2	13

Table 3: Top cited journals.

Rank	Journal	No. of Publications	Citations
1	Algorithms	1	32
2	Journal of Organizational and End User Computing	1	29
3	IEEE Transactions on Learning Technologies	1	19
4	Mobile Information Systems	4	17
5	Journal of Supercomputing	1	17
6	Education and Information Technologies	2	15
7	Frontiers in Psychology	2	9
8	Big Data and Cognitive Computing	1	9
9	Education Economics	1	9
10	Journal of Universal Computer Science	1	9

Table 4: Top cited authors.

Rank	Author	No. of Publications	Citations
1	Chen, Long-sheng	2	41
2	Thao-trang Huynh-cam	2	41
3	Huynh Le	1	32
4	Luo, Zhilin	1	29
5	Ma, Xiaochun	1	29
6	Shao, Xuefeng	1	29
7	Lang, Qi	1	19
8	Liang, Shuang	1	19
9	Song, Wenzhuo	1	19
10	Wang, Minjuan	1	19

4.3. Keyword Co-occurrence Analysis

The keyword co-occurrence analysis generated four clusters, as shown in Figure 2, indicating that research on artificial intelligence in vocational education is organized around several interrelated but distinguishable thematic areas spanning both technological and pedagogical concerns. Cluster 1 represents a technology-oriented strand centered on data-driven methods and immersive learning environments. The co-occurrence of keywords such as machine learning, neural network, big data, analytics, and algorithmic models indicates a strong focus on intelligent data processing and model-based evaluation. At the same time, the presence of virtual reality, digital technologies, and environment suggests that these analytical approaches are frequently integrated with simulation-based training contexts. Cluster 2 captures a line of research focused on generative AI and intelligent instructional support. Keywords such as chatbots, large language model, prediction, performance, and virtual laboratory indicate an emphasis on AI-enabled interaction, feedback, and adaptive support. Compared with Cluster 1, which is more oriented toward technological infrastructure and training systems, this cluster highlights learner-facing applications and real-time instructional assistance. The inclusion of terms such as students and survey further suggests that this strand often incorporates evaluative perspectives on user experience and learning effectiveness. Cluster 3 reflects a learner-centered perspective on AI in vocational education. The presence of keywords such as AI literacy, academic achievement, motivation, self-efficacy, and framework indicates a growing interest in how AI influences learners' competences, engagement, and educational outcomes. While technical terms such as decision tree and artificial neural networks also appear, they are embedded within a broader focus on learner development and conceptual understanding. This cluster suggests that research is increasingly examining the role of AI in shaping students' readiness and adaptability in technology-enhanced learning environments. Cluster 4 is associated with discipline-specific applications and future-oriented educational development. Keywords such as English, design, deep learning, personalized learning model, talent cultivation, and future indicate that AI is being linked to subject teaching, curriculum innovation, and long-term workforce preparation. This cluster reflects a shift toward integrating AI into specific domains of vocational education, as well as broader discussions on how education systems can respond to evolving industry needs.

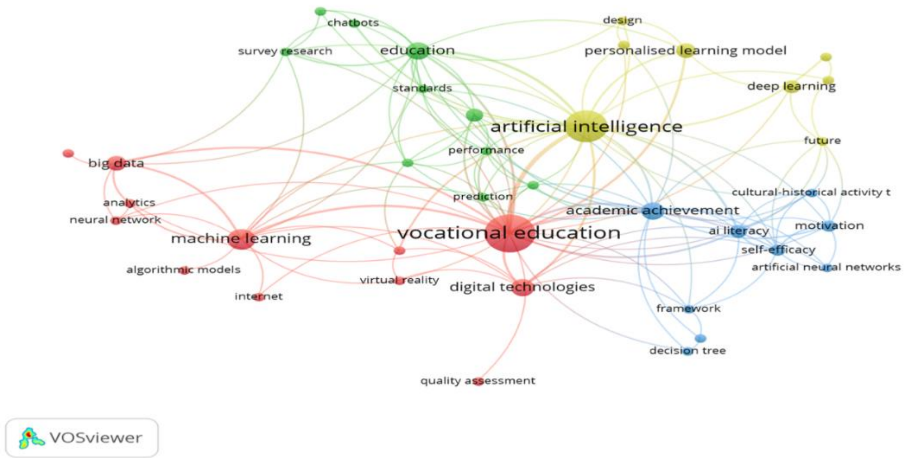

Figure 2: Keyword co-occurrence network of AI research in vocational education.

5. Discussion

Research on artificial intelligence in vocational education has grown rapidly, especially after 2020, reflecting the wider diffusion of AI technologies and the accelerated digitalization of education during the COVID-19 period. Consistent with previous studies on adaptive learning, automated assessment, prediction, and learner support [1–3], this growth suggests that vocational education is increasingly involved in broader AI-driven educational transformation. The contributor analysis shows an uneven distribution of influence. Although China produced the largest number of publications and citations, several contributors with fewer publications also achieved notable citation impact, indicating that influence depends not only on output volume but also on the relevance and visibility of key studies [21]. Keyword analysis reveals a shift from earlier emphases on system development, automation, and technological efficiency toward academic achievement, AI literacy, personalized learning, and learner support. In vocational education, this shift is important because AI is being explored not only as a technical tool, but also as a means of supporting applied learning, skills development, and future workplace readiness.

Overall, the field is expanding quickly, but its structure and themes remain evolving. Future research should better connect AI innovation with pedagogical design and vocational learning outcomes.

6. Conclusion

This study provides a bibliometric overview of research on artificial intelligence in vocational education by examining publication trends, contributor structures, and thematic patterns. The results show that the field has shifted from limited and sporadic activity to rapid expansion in recent years, although this growth remains uneven. Scholarly influence is concentrated among a relatively small number of countries, institutions, journals, and authors, suggesting that the research landscape has not yet fully stabilized. The thematic structure also indicates a gradual change in research focus. While technological approaches such as machine learning and data-driven systems remain central, increasing attention is being paid to learning outcomes, personalized instruction, and AI literacy. This suggests that artificial intelligence is increasingly being examined not only as a technical tool, but also as a factor shaping learning processes and learner development in vocational contexts. Future research should therefore pay closer attention to how AI supports vocational learning, practical skill development, and learner readiness for technology-enhanced workplaces.

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