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Digital Education and Curriculum Design: A Scientometric Analysis (2005–2025)

Rani Laylatul Fitriya [a,1,*], Muhammad Fahdi Askbar [b,2], Aulia Mukhlisa [c,3], Desy Dwi Putri [d,4], Resky Nuralisa Gunawan [e,5]

[a] Universitas Negeri Yogyakarta, Jalan Colombo No.1, Yogyakarta 55281, Indonesia
[b] Universitas Saintek Muhammadiyah Jakarta, Jalan Raya Klp. Dua Wetan No.17 7, DKI Jakarta, 13730, Indonesia
[c] Universitas Negeri Makassar, Sulawesi Selatan, Indonesia
[d] Khon Kaen University, Nai Mueang, Mueang Khon Kaen District, Khon Kaen 40002, Thailand
[e] Peneliti Teknologi Teknik Indonesia, Indonesia
[1] ranilaylatul.2022@student.uny.ac.id; [2] fahdiakbar05@gmail.com; [3] auliamukhlisa10@gmail.com;
[4] desy.p@kkumail.com; [5] reskynuralisa.2022@student.uny.ac.id
* Corresponding Author

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ABSTRACT

The landscape of education has been significantly transformed by the rapid advancement of digital technologies. However, the intersection between digital education and curriculum design remains fragmented, with limited comprehensive mapping of its thematic growth and innovation. To address this gap, this study aims to provide a scientometric review of the literature from 2005 to 2025, identifying key trends, research hotspots, and emerging directions in this domain. This research offers a consolidated view of the field's evolution and intellectual structure, with particular attention to how novel technologies shape curriculum strategies and student engagement. The key contribution of this study lies in its dual focus on digital education and curriculum design, its use of longitudinal data, and its identification of emerging keywords that signal the future direction of educational transformation. Furthermore, the findings offer actionable insights to inform strategic decision-making by educators, researchers, and policymakers. A scientometric method was employed, using data extracted from the Scopus database. From an initial dataset of 11,288 publications, a final sample of 3,558 documents was analyzed following a rigorous multi-stage screening process. The analysis utilized bibliometric mapping through VOSviewer to identify co-occurring keywords, publication trends, and thematic clusters across two decades. Results indicate a sharp increase in scholarly output after 2018, correlating with the global acceleration of digital transformation in education. Core themes include curriculum design, student-centered learning, and assessment. Meanwhile, emerging keywords Artificial Intelligence, Blockchain, Machine Learning, Big Data, Digital Transformation, and Inclusive Education reveal a shift toward more adaptive, data-driven, and equitable models of learning. These keywords are increasingly connected to foundational educational terms, signaling their integration into mainstream academic discourse. In conclusion, this study validates the hypothesis that digital technologies are reshaping curriculum priorities while offering a forward-looking roadmap for future research. It contributes not only to academic understanding but also to the development of future-ready educational systems.

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1. Introduction

Over the past two decades, digital technologies have significantly transformed educational systems across the globe. The integration of digital tools, platforms, and pedagogical strategies has shifted curriculum design from static, content-centered delivery toward dynamic, learner-centered models that are adaptable, data-driven, and aligned with 21st century competencies [1], [2], [3], [4], [5]. This evolution is not merely technical it reflects broader epistemological changes in how knowledge is created, accessed, and assessed in modern education [6], [7], [8]. As a result, new paradigms in curriculum design have emerged, including personalized learning paths, competency-based education, interdisciplinary curricula, and technology-enhanced assessments [9], [10], [11].

Despite this rapid transformation, scholarly work on the intersection of digital education and curriculum design remains fragmented across multiple subdomains. Prior scientometric studies have primarily focused on isolated elements such as e-learning [12], mobile learning [13], and gamification [14], without offering an integrated perspective that connects these elements with curriculum development strategies. Moreover, only a limited number of studies [15], [16], [17] have attempted to map the intellectual structure of this field over a long period of time. Therefore, there is a clear research gap in providing a holistic and temporal understanding of how digital education and curriculum design intersect and evolve.

The novelty of this study lies in its dual focus examining both digital education and curriculum design simultaneously over a 20-year span, which has rarely been done in prior reviews. It also introduces emerging keywords such as Artificial Intelligence, Blockchain, Digital Transformation, Machine Learning, and Knowledge Management into curriculum discourse, showing how these concepts are beginning to shape the future of educational design and policy. Drawing on insights from more than 20 prior bibliometric and theoretical studies (e.g., Chiu T, Ng D, Walter Y, Ghamrawi N, Sato M,) [18], [19], [20], [21], [22], this review offers a comprehensive overview that can inform future investigations, educational policy decisions, and strategic curriculum planning. The contribution of this study is to clarify the intellectual landscape of this field and offer evidence-based guidance for researchers, educators, and decision makers navigating digital transformation in education.

This study seeks to fill that gap by conducting a scientometric review of the literature on digital education and curriculum design between 2005 and 2025. Specifically, this study aims to: (Q1) Identify the thematic evolution, research hotspots, and intellectual structure of the field and (Q2) Suggest future research directions based on keyword co-occurrences and emerging trends.

The key contributions of this paper are threefold and aim to advance scholarly understanding in the evolving intersection between digital education and curriculum design. First, it offers a longitudinal bibliometric map that captures the thematic evolution and knowledge structure of this fragmented yet increasingly significant educational domain. This mapping provides a comprehensive overview of how the field has developed over two decades, identifying key research milestones and dominant publication trends. Second, the paper uncovers underexplored research clusters and emerging frontiers, particularly those linked to Education 4.0 and the broader processes of digital transformation in education. These insights reveal gaps in current literature that offer promising avenues for further inquiry. Third, the study provides strategic implications for a wide range of stakeholders including researchers, educators, and policymakers who are seeking to align curriculum innovation with rapidly evolving technological trends. By offering evidence-based insights, this study contributes to the design of forward-looking educational systems that are adaptive, inclusive, and responsive to future learning needs.

The remainder of the paper is structured to guide the reader through a logical and methodologically grounded exploration of the topic. Section 2 introduces the scientometric methodology, including the selection criteria, data sources, and analytical tools used in the study. This section establishes the methodological rigor and reliability of the findings. Section 3 presents the core results, highlighting publication trends, influential authors, and co-occurrence networks of key terms. This analysis also identifies the novelty keywords such as artificial intelligence, blockchain, and

machine learning that are gaining traction in curriculum discourse. Section 4 interprets these findings by discussing future research directions and outlining their implications for both theory and practice. Finally, Section 5 concludes the study with a synthesis of insights and a proposed roadmap for integrating digital technologies into curriculum design, ensuring the relevance and sustainability of educational innovation in the years to come.

2. Method

This study employed a scientometric approach to systematically identify and analyze scholarly publications related to digital education and curriculum design over a two-decade period (2005–2025). Data were retrieved from the Scopus database, one of the most comprehensive and multidisciplinary bibliographic databases for peer-reviewed literature. The search strategy used a combination of Boolean operators and specific keywords in the fields of title, abstract, and keywords (TITLE-ABS-KEY), using the query: TITLE-ABS-KEY ("digital education") OR TITLE-ABS-KEY ("curriculum design") AND PUBYEAR > 2005 AND PUBYEAR < 2025. This search yielded an initial dataset of 11,288 documents.

In the screening phase, the metadata of all retrieved documents were examined to remove duplicates and records with insufficient thematic relevance, resulting in 8,880 documents deemed potentially eligible. These documents were subsequently subjected to a full-text screening to assess their alignment with the inclusion criteria, which consisted of: (1) being published in peer-reviewed journals; (2) written in English; (3) containing empirical or theoretical contributions related to digital education and/or curriculum design; and (4) possessing complete bibliographic metadata required for scientometric analysis. During this eligibility assessment, 5,322 documents were excluded due to irrelevance, incomplete metadata, or non-compliance with scholarly standards (e.g., editorials, opinion pieces, or non-academic sources).

After this multi-stage filtration process, a total of 3,558 documents were included in the final dataset and subjected to bibliometric analysis. These publications provided a robust basis for mapping scientific productivity, research trends, influential authors and institutions, co-citation networks, and thematic clusters within the intersection of digital education and curriculum design.

To clarify the research process, Fig. 1 outlines the methodological workflow using four sequential stages:

1. Identification: The stage where records are gathered from the Scopus database using defined search terms and year range, resulting in 11,288 initial documents.
2. Screening: At this phase, records are examined for basic relevance and metadata completeness. Documents that did not match the core themes or were duplicated were removed, narrowing the pool to 8,880.
3. Eligibility: A more detailed evaluation is conducted through fulltext screening and keyword checks. At this point, documents were filtered based on publication type, subject area, and language.
4. Included: Final selection resulted in 3,558 eligible documents that met all quality and relevance standards. These were used as the dataset for the bibliometric analysis.

3. Results and Discussion

3.1. Scientific Publications on Digital Education and Curriculum Design Evolved over the Last Two Decades

The trend displayed in Fig. 2, "Documents by Year," shows a significant and consistent increase in the number of publications related to digital education and curriculum design from 2008 to 2024. In the early phase (2008–2014), the growth appears relatively stagnant with only minor increases each year, fluctuating between 50 to 100 documents annually. However, starting from 2016, a notable

upward trend is observed, with a steady rise in scholarly output. The acceleration becomes more pronounced after 2018, and the number of publications surged significantly, reaching its peak in 2024 with more than 600 documents published. This indicates growing scholarly interest and the increasing relevance of these topics over time.

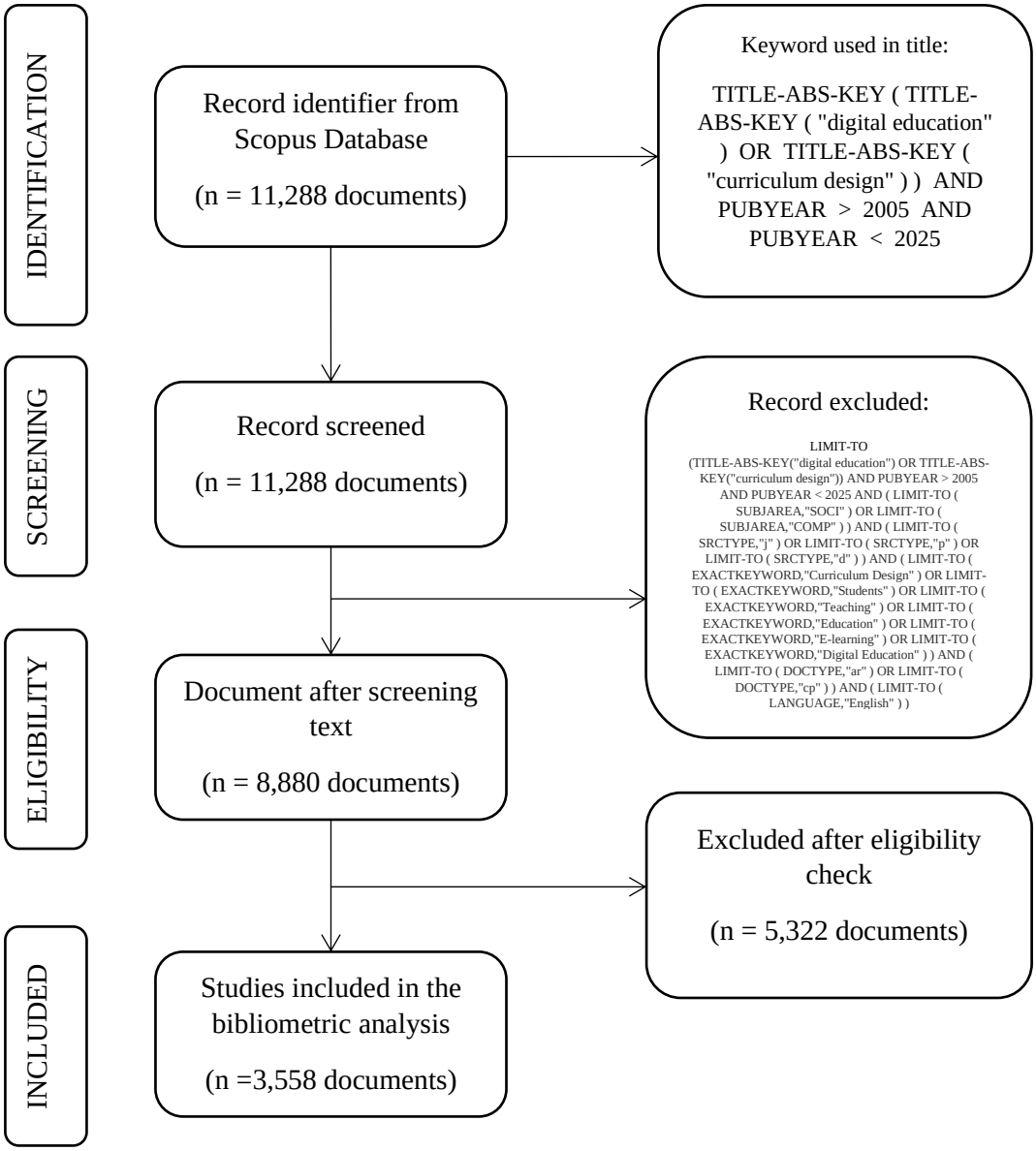

Fig. 1. The proposed method

The sharp rise in publication output, especially after 2018, may reflect the global shift toward integrating digital technologies in education, curriculum reform aligned with digital competencies, and increased academic attention to educational innovation. Although the pandemic is not referenced directly in this study, the general global transition to digital tools across education sectors likely contributed to the surge in research. Moreover, the year 2024 marks the highest number of publications, which suggests that the topic continues to gain momentum and has not yet reached saturation. This growth trend supports the relevance of conducting a scientometric analysis at this point in time, as it offers a strategic opportunity to map knowledge development, identify influential research clusters, and propose future research directions that align with evolving educational needs and digital transformations.

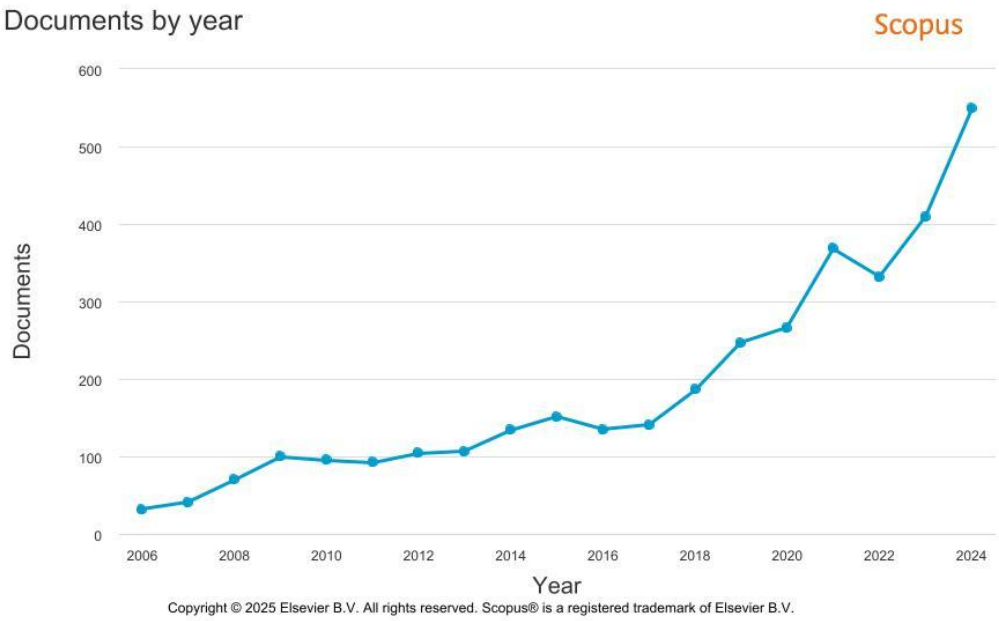

Fig. 2. Documents by year

The donut chart in Fig. 3 illustrates the distribution of publication types in the dataset analyzed. The majority of documents are conference papers, comprising 51.6% of the total. This is followed by journal articles at 25.8%, and book chapters at 12.9%. Other types of documents include reviews (6.5%) and short surveys (3.2%). This data shows that more than half of the scholarly output related to digital education and curriculum design is disseminated through conference proceedings rather than peer-reviewed journals.

The dominance of conference papers indicates that the field of digital education and curriculum design is dynamic and still emerging, with researchers often opting to present preliminary findings or conceptual frameworks in academic conferences. This is typical for fast developing disciplines where rapid dissemination and feedback are essential. While journal articles and book chapters offer more in depth and peer reviewed contributions, their smaller proportion suggests that high-impact, consolidated research in this domain may still be developing. The relatively low number of review papers highlights a potential gap and opportunity for future researchers to synthesize existing literature and contribute to the theoretical consolidation of this growing field.

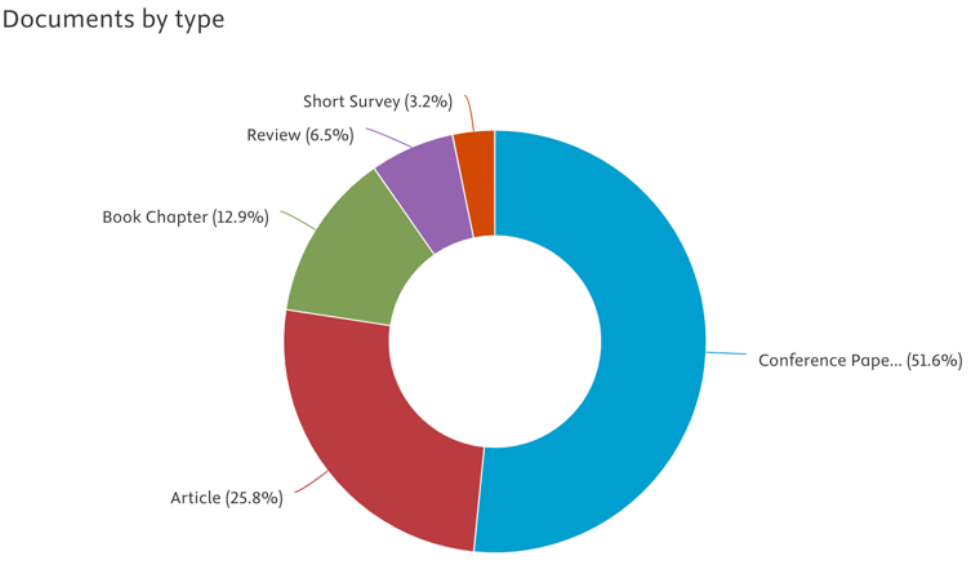

Fig. 3. Documents by type

The bibliometric visualization in Fig. 4 presents a comprehensive co-occurrence network of keywords associated with digital curriculum design and education from 2005 to 2025. The most prominent terms, such as "curriculum design" and "students," are displayed with larger nodes, indicating their high frequency and centrality in the literature. Closely connected terms like "assessment," "digital transformation," "information technology," and "learning outcomes" reveal the main thematic clusters that dominate this research domain. The visual proximity of keywords demonstrates the interrelatedness of concepts, particularly highlighting the integration of digital tools and educational frameworks. Clusters of colors represent different thematic areas, with blue and green denoting core academic and technological concerns. Terms such as "data mining," "digital literacies," and "cloud computing" show emerging interest in data-driven and tech-enhanced approaches to curriculum design. Overall, the map reveals that research in digital curriculum design is multifaceted, converging around pedagogy, technology, student engagement, and learning outcomes.

This network visualization underscores the evolving priorities in educational research, with digital transformation emerging as a core concern in curriculum development. The dominant position of "students" suggests a strong orientation toward learner centered frameworks, where student needs and outcomes guide pedagogical innovation. Technological elements like "information technology," "big data," and "online education" point to the accelerating adoption of digital tools in instructional design and delivery. These developments reflect global trends where educators are reimagining curricula to fit digital first or hybrid learning environments. The keyword "assessment" being centrally positioned also indicates the importance of evaluating student performance in technologically enriched contexts. Meanwhile, peripheral yet connected terms such as "collaboration," "universal design," and "professionalism" suggest ongoing interest in inclusive practices and faculty development. Collectively, the map not only captures historical trends but also provides a strategic lens for identifying future research directions in digital education and curriculum studies.

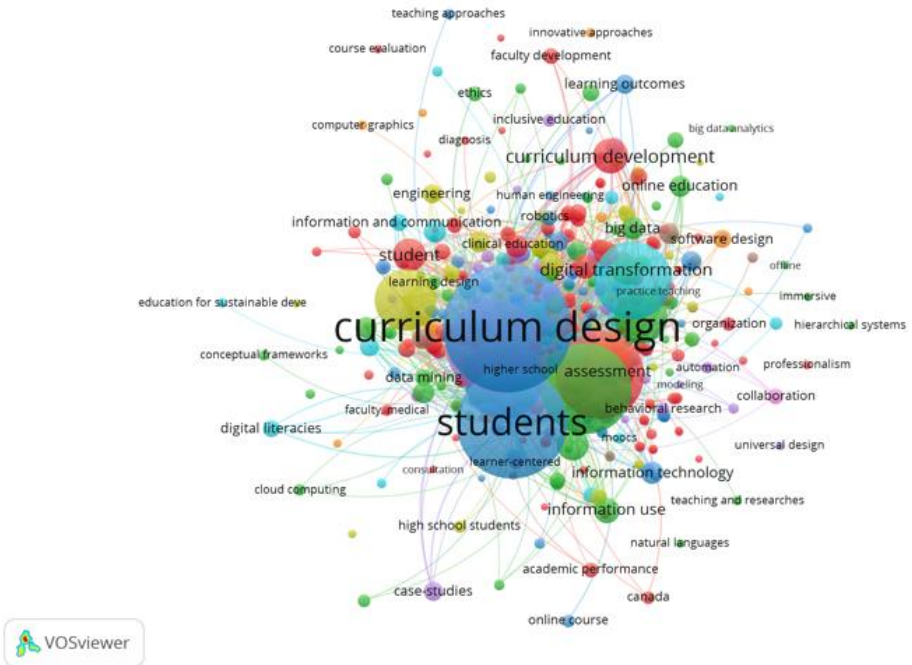

Fig. 4. Focus Research

The results show a significant and steady rise in scientific publications related to digital education and curriculum design, particularly from 2018 onward. Between 2008 and 2014, publication numbers remained relatively stable, fluctuating between 50-100 per year. However, after 2018, a dramatic increase is observed, peaking in 2024 with over 600 publications. This pattern aligns with findings from Satchanawakul N [23] , who also identified a surge in education technology research following major shifts in global education delivery models. The sharp rise can be partially attributed to the COVID-19 pandemic, which accelerated the adoption of digital tools and remote learning worldwide.

Additionally, various national digital education strategies, such as UNESCO's Global Education Coalition and government-mandated EdTech integration, provided a systemic push toward digitization in curriculum design. These external factors not only catalyzed innovation but also stimulated scholarly interest, leading to a rapid expansion of the field.

The keyword co-occurrence analysis confirms that the literature has transitioned from focusing solely on core educational concepts like "students" and "curriculum design" to exploring novel themes such as "digital transformation," "AI," "blockchain," and "machine learning." Compared with prior studies such as Dorry R [24], this study provides a more integrated and longitudinal perspective by combining curriculum design with digital education trends. The thematic clusters show a move from pedagogy-centric approaches to data-driven and personalized models, where the role of technology is no longer supplemental but central. These shifts reflect deeper pedagogical transformations aligned with Education 4.0, emphasizing adaptability, real-time feedback, and lifelong learning. For instance, the inclusion of "inclusive education" and "knowledge management" in recent years indicates growing concerns about equity and institutional readiness in digital transformation.

3.2. Emerging Directions for Future Research in Digital Curriculum Design

The visualized co-occurrence map in Fig. 5 highlights the key thematic structure of research concerning Education 4.0, particularly in the context of curriculum development and student-centered learning. Dominant keywords such as curriculum design, students, digital transformation, assessment, and information technology appear centrally and with large node sizes, indicating their high frequency and centrality in the literature. The density and thickness of the links between nodes suggest a tightly interconnected research network, with many keywords co-occurring across various publications. Temporal coloring, ranging from blue (older studies) to yellow (more recent studies), reveals that more current research (2020–2022) has increasingly emphasized topics like big data, digital transformation, inclusive education, and blockchain. Peripheral terms like robotics, cloud computing, and natural languages show growing relevance but remain less central. This suggests an expanding scope of Education 4.0 toward integrating emerging technologies into pedagogy. Overall, the map illustrates how technological advancements are reshaping curriculum priorities with students at the core.

The co-occurrence map illustrates a dynamic shift in education research from traditional instructional design toward a technology-integrated learning environment. Central concepts such as curriculum design and students remain foundational, indicating ongoing concern with the structure of educational delivery and its impact on learners. The emergence of digital transformation, data mining, and online education reflects a growing emphasis on leveraging data and technology to personalize learning experiences. The prominence of assessment and learning outcomes suggests researchers are actively evaluating the effectiveness of these new pedagogical approaches. The linkages among terms like faculty development, collaboration, and teaching and research point to a system-wide shift in how education professionals adapt to rapid technological change. The temporal gradient shows that innovations like big data, inclusive education, and cloud computing are gaining traction, highlighting their novelty and research momentum. Collectively, this evolving network structure demonstrates that Education 4.0 is not only reshaping what is taught but also how teaching and learning processes are conceptualized and measured.

A deeper look into emerging keywords reveals a notable focus on novelty-driven concepts like artificial intelligence, blockchain, machine learning, digital transformation, and knowledge management. These terms, while not yet central, are clearly increasing in presence and connectivity within the network, as indicated by their lighter (yellow-green) hues signifying recent publication years. Digital transformation appears closest to the core cluster, suggesting it is already becoming integral to curriculum discourse. Artificial intelligence and machine learning are associated with automation, immersive learning, and educational modeling, implying their potential to support adaptive learning systems. The presence of blockchain hints at explorations into educational data security, credentialing, and transparency. Knowledge management connects with organizational learning and faculty development, pointing to the need for institutional readiness in managing

educational innovation [25], [26], [27], [28]. These developments suggest that Education 4.0 is no longer theoretical; it is actively being operationalized through smart technologies and system redesigns. In the coming years, these keywords are likely to migrate further toward the center of research focus.

From a policy and practice standpoint, these findings have several key implications. First, educational policymakers should leverage these trends to formulate evidence-based digital curriculum policies that emphasize inclusivity and adaptability. Second, educators and school leaders should be trained in emerging technologies, particularly AI and big data, to enhance learning personalization and assessment strategies. Third, curriculum developers should consider integrating blockchain for credentialing, machine learning for predictive analytics, and knowledge management for institutional learning. As shown by temporal clustering, these concepts are becoming more central and should be incorporated into curriculum design frameworks going forward. Additionally, universities and teacher-training institutions should prioritize interdisciplinary collaboration between education, computer science, and data ethics to build a sustainable digital learning ecosystem. Future research should investigate longitudinal impacts of these technologies and explore contextual adaptations in low-resource educational environments. By doing so, the digital transformation of education can be aligned not only with technological potential but also with pedagogical integrity and social justice.

Future research should delve deeper into the pedagogical and systemic implications of emerging technologies such as artificial intelligence, blockchain, and machine learning within curriculum design and student engagement. As these concepts continue to appear more frequently in recent studies, there is a growing need to explore their practical applications and measurable impacts on educational outcomes [29], [30], [31]. Investigations should focus on how AI-driven personalization, blockchain-enabled credentialing, and data-driven decision-making can enhance inclusivity, transparency, and adaptability in K–12 and higher education settings [32]. Longitudinal studies that assess how these technologies influence both teacher practices and student learning behaviors over time would be particularly valuable. Additionally, interdisciplinary research combining education, computer science, and cognitive psychology could provide richer insights into the efficacy and ethics of tech-enhanced learning environments. Future work should also consider equity issues, ensuring that digital transformation benefits are accessible across diverse socioeconomic and cultural contexts. By addressing these gaps, researchers can support the responsible integration of cutting-edge tools into the evolving educational landscape of Education 4.0.

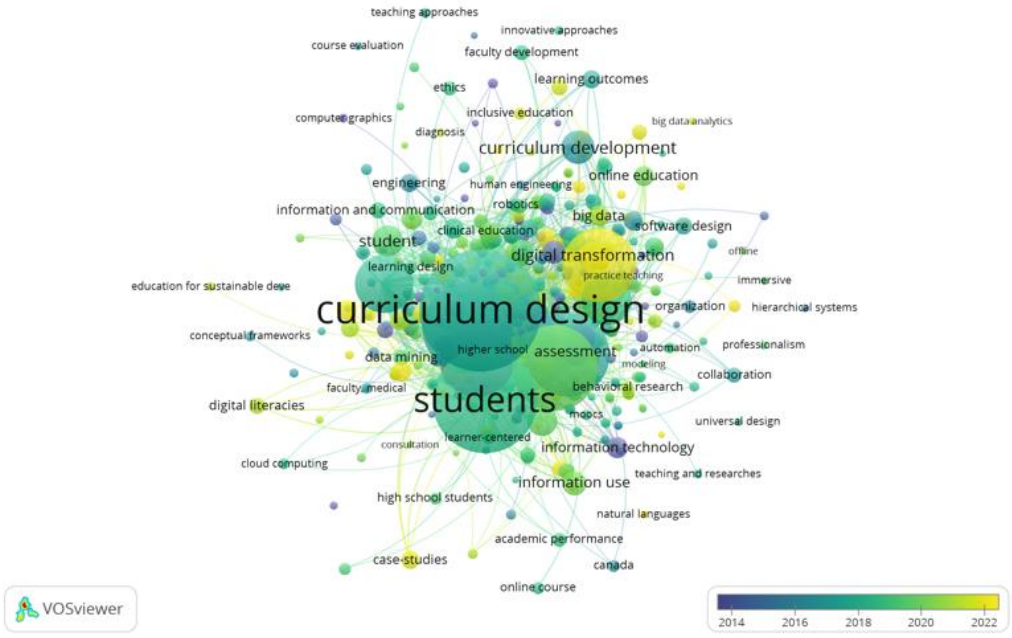

Fig. 5. Keywords Novelty

4. Conclusion

This study successfully reveals how digital transformation is reshaping curriculum design and student engagement through emerging technological innovations. The results and discussion sections confirmed a significant rise in scholarly focus on novel concepts such as Artificial Intelligence, Blockchain, Machine Learning, Big Data, Digital Transformation, and Inclusive Education. These keywords, which appeared prominently in recent publications, indicate an evolving research trajectory where technology does not merely support instruction but becomes a central force in redesigning learning environments. The co-occurrence and temporal visualizations demonstrated that while these terms were once peripheral, they are now progressively integrated into core educational themes. Their growing connectivity with foundational keywords like curriculum design, students, and assessment shows strong alignment with the study's aim to explore future-ready educational paradigms. Looking ahead, these findings open prospects for developing adaptive, data-driven, secure, and inclusive educational systems that respond to diverse learner needs. Further research should examine the implementation, effectiveness, and ethical dimensions of these technologies, ensuring that their integration enhances not replaces pedagogical purpose. In this way, the study not only achieves its objectives but also contributes a roadmap for advancing Education 4.0 through targeted and forward-looking scholarship.

Based on these findings, future research should explore the practical applications and long-term impacts of these technologies on curriculum implementation, student outcomes, and institutional policy. In particular, longitudinal and comparative studies are needed to assess how digital innovations influence learning equity, teacher roles, and cross-cultural curriculum frameworks. Researchers are encouraged to engage in interdisciplinary collaborations combining education, data science, and cognitive psychology to uncover deeper insights into pedagogical design. For educators, there is a need to build digital competencies that align with emerging instructional models such as AI-powered personalization and blockchain-based credentialing. Policymakers should support the development of scalable and inclusive digital curriculum frameworks through investment in infrastructure, training, and open-access resources. Curriculum developers must consider integrating data ethics, real-time analytics, and student agency as core principles in future curriculum models. Collectively, these efforts can ensure that educational transformation through technology is intentional, inclusive, and impactful. This study contributes not only a comprehensive research map but also a strategic starting point for stakeholders committed to advancing the vision of Education 4.0.

Declaration

Supplementary Materials: Supplementary materials of this study include the full dataset retrieved from Scopus and visualizations generated using VOSviewer.

Author Contributions: RLF & MFA: Conceptualization; RNG: Writing-Initial Draft, Editing and Visualization, Methodology and Review & Editing, Conceptualization, Formal analysis, Methodology and Review & Editing; AM & DDP: Validation and Monitoring. All authors have read and approved the published version of the manuscript.

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