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Mapping the Digital Transformation of Education in Indonesia from 2012 to early 2025: A Bibliometric Analysis of Scopus-Indexed Publications

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ABSTRACT

The digital transformation of education in Indonesia has accelerated significantly, particularly after the COVID-19 pandemic. National initiatives like Merdeka Belajar have emphasized digital integration in teaching and learning, prompting scholarly interest in e-learning, online pedagogy, and technology-enhanced instruction. Despite this growing body of literature, there remains a lack of systematic analysis regarding how this research has evolved, which themes have dominated, and how collaboration networks have developed. This study aims to map the research landscape of digital education in Indonesia by conducting a bibliometric analysis of Scopus-indexed journal articles published between January, 1, 2012 and May, 31, 2025. Using the Biblioshiny interface of the R-based Bibliometrix package, 1,131 articles were analyzed to examine publication trends, thematic patterns, prominent keywords, top contributing authors and institutions, and the evolution of co-authorship networks. The results show a notable increase in publication volume beginning in 2020, coinciding with the national shift to online learning. Key research themes include "e-learning", "online learning", and "blended learning", while emerging topics such as "digital literacy", "gamification", and "student engagement" reflect new pedagogical directions. Leading institutions include Universitas Negeri Malang, Universitas Pendidikan Indonesia, and Universitas Negeri Yogyakarta, with collaboration patterns showing modest but growing international engagement. This study offers a comprehensive overview of how digital transformation has been addressed in Indonesian educational research and provides insights into its future trajectory. The findings serve as a reference for researchers, educators, and policymakers in identifying research gaps and shaping strategic directions for digital education.

Keywords: *digital transformation, educational technology, bibliometric analysis, Biblioshiny, Scopus, Indonesia.*

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INTRODUCTION

The global shift toward digitalization in education, often called 'digital transformation', has significantly influenced how teaching, learning, and assessment are conducted.[1] Driven by the swift progression of information and communication technologies (ICT), digital learning environments have evolved from auxiliary resources into essential elements of formal educational frameworks.[2] The COVID-19 pandemic further accelerated this transition by necessitating emergency remote teaching, which, in turn, drove institutional investments in online platforms, teacher training, and digital content.[3]

In Indonesia, the government has responded through various national policy initiatives such as the *Merdeka Belajar* program,[4] which emphasizes autonomy,[5] flexibility,[6] and innovation in learning,[7] often supported by digital tools.[8] These initiatives have increased scholarly attention toward e-learning adoption,[9] blended learning implementation, digital literacy,[10] and online pedagogical strategies.[11] However, despite the increasing number of

[1] Mamdouh Alenezi, Saja Wardat, and Mohammed Akour, "The Need of Integrating Digital Education in Higher Education: Challenges and Opportunities," *Sustainability* 15, no. 6 (March 8, 2023): 4782, https://doi.org/10.3390/su15064782; Melissa Bond et al., "Digital Transformation in German Higher Education: Student and Teacher Perceptions and Usage of Digital Media," *International Journal of Educational Technology in Higher Education* 15, no. 1 (December 28, 2018): 48, https://doi.org/10.1186/s41239-018-0130-1; Daniel Jahja Surjawan, Armein Z. R. Langi, and Radiant Victor Imbar, "Digital Transformation for Institution Operations in Higher Education: A Literature Review," *IEEE Access* 13 (2025): 61457–68, https://doi.org/10.1109/ACCESS.2025.3557446.

[2] Elena V. Frolova, Olga V. Rogach, and Tatyana M. Ryabova, "Digitalization of Education in Modern Scientific Discourse: New Trends and Risks Analysis," *European Journal of Contemporary Education* 9, no. 2 (June 12, 2020), https://doi.org/10.13187/ejced.2020.2.313; Nguyen Thi Phuong Giang, Le Thi Hong Nhung, and Nguyen Binh Phuong Duy, "Increasing Intention to Continue Participating in Digital Transformation among SMEs: Partial Least Squares Structural Equation Modeling (PLS-SEM) Analysis Using R," *International Journal of Analysis and Applications* 23 (May 8, 2025): 110, https://doi.org/10.28924/2291-8639-23-2025-110.

[3] Yu Zhao et al., "Adapting to Crisis and Unveiling the Digital Shift: A Systematic Literature Review of Digital Competence in Education Related to COVID-19," *Frontiers in Education* 10 (March 25, 2025), https://doi.org/10.3389/feduc.2025.1541475; Lucas Cone et al., "Pandemic Acceleration: Covid-19 and the Emergency Digitalization of European Education," *European Educational Research Journal* 21, no. 5 (September 1, 2022): 845–68, https://doi.org/10.1177/14749041211041793; Byeongwoo Kang, "How the COVID-19 Pandemic Is Reshaping the Education Service," 2021, 15–36, https://doi.org/10.1007/978-981-33-4126-5_2; Claudia E. Stoian et al., "Transition from Online to Face-to-Face Education after COVID-19: The Benefits of Online Education from Students' Perspective," *Sustainability* 14, no. 19 (October 7, 2022): 12812, https://doi.org/10.3390/su141912812.

[4] Husnul Haq and Wakidi, "Evaluation of the Implementation of the Merdeka Belajar Curriculum in Secondary Schools in the Digital Era," *International Journal of Post Axial: Futuristic Teaching and Learning*, August 30, 2024, 215–28, https://doi.org/10.59944/postaxial.v2i4.391.

[5] Aidatul Fitriyah, Ummi Aminah, and Awalina Dea Safitri, "Educational Innovation Through the Independent Learning Initiative in Indonesia," *Eduscape : Journal of Education Insight* 2, no. 4 (October 30, 2024): 240–49, https://doi.org/10.61978/eduscape.v2i4.446.

[6] M. Yusuf and Witrialail Arfiansyah, "Konsep 'Merdeka Belajar' Dalam Pandangan Filsafat Konstruktivisme," *AL-MURABBI: Jurnal Studi Kependidikan Dan Keislaman* 7, no. 2 (January 14, 2021): 120–33, https://doi.org/10.53627/jam.v7i2.3996.

[7] Fitriyah, Aminah, and Safitri, "Educational Innovation Through the Independent Learning Initiative in Indonesia."

[8] A I Sari et al., "Digital Learning, Smartphone Usage, and Digital Culture in Indonesia Education," *Integration of Education* 24, no. 1 (2020): 20–31, https://doi.org/10.15507/1991-9468.098.024.202001.020-031.

[9] Ummi Salamah, Yuni Listiyani, and Mustafiyanti Mustafiyanti, "Analisis Konsep Dan Struktur Kurikulum Merdeka Dan Merdeka Belajar," *Khatulistiwa: Jurnal Pendidikan Dan Sosial Humaniora* 4, no. 2 (May 30, 2024): 123–29, https://doi.org/10.55606/khatulistiwa.v4i2.3234.

[10] Adison Adrianus Sihombing et al., "Merdeka Belajar in an Online Learning during The Covid-19 Outbreak: Concept and Implementation," *Asian Journal of University Education* 17, no. 4 (November 25, 2021): 35, https://doi.org/10.24191/ajue.v17i4.16207.

[11] Mulyo Prayitno and Moh Rosyid Mahmudi, "Effectiveness of the Merdeka Belajar Policy: Challenges and Opportunities in Improving the Quality of Primary and Secondary Education in Indonesia," *MANDALIKA : Journal of Social Science* 3, no. 1 (February 28, 2025): 16–21, https://doi.org/10.56566/mandalika.v3i1.290.

studies, the field remains fragmented, lacking a unified synthesis of its development over time.

Several prior bibliometric studies have attempted to explore digital education and its subfields in Indonesia. Aulia and Tasrif (2025) used the Sinta database to examine digital literacy research in Indonesian education. They found that studies mainly focus on pedagogical use, with Java dominating research output.[12] However, their analysis excluded Scopus-indexed literature and lacked temporal segmentation. Similarly, Husaeni et al. (2023) mapped educational research indexed by Google Scholar from 2017 to 2021, but did not focus on digital transformation specifically.[13] Watrianthos et al. (2022) conducted a bibliometric analysis of vocational education using the Dimensions database, yet the focus was limited to SMK-related publications.[14] Other works, such as Mahayanti et al. (2025), explored peace education trends,[15] While Wigati (2021) provided insights on the use of machine learning in educational development,[16] However, found only 2.6% of relevant publications were related to education.

These studies indicate that, while bibliometric approaches are increasingly used in Indonesian education research,[17] a gap remains in comprehensively mapping the evolution of digital transformation themes in Scopus-indexed literature. To the best of our knowledge, no existing study has systematically analyzed publication trends, thematic structures, and collaboration networks on the digital transformation of education in Indonesia using a global citation index and covering an extended timeline (2012–2025). This study, therefore, represents a novel and pioneering effort in the field, addressing this gap through a detailed bibliometric analysis using Scopus as the data source.

The primary objective of this study is to provide a comprehensive bibliometric overview of the scientific landscape concerning the digital transformation of education in Indonesia. By analyzing Scopus-indexed journal publications from 2012 to early 2025, this study aims to uncover key patterns in research productivity, thematic focus, and scholarly collaboration. Specifically, the study seeks to (1) map the evolution of publication trends over time, (2) identify the most frequently studied topics and prominent keywords, (3) determine the

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[12] Febrina Aulia and Elfi Tasrif, "Bibliometric Analysis of Research Trends in Digital Literacy within Indonesian Education: Development, Challenges, and Opportunities," *Jurnal Pendidikan MIPA* 26, no. 1 (May 6, 2025): 595–611, https://doi.org/10.23960/jpmipa.v26i1.pp595-611.

[13] Dwi Fitria Al Husaeni, Asep Bayu Dani Nandiyanto, and Rina Maryanti, "Bibliometric Analysis of Educational Research in 2017 to 2021 Using VOSviewer: Google Scholar Indexed Research," *Indonesian Journal of Teaching in Science* 3, no. 1 (September 18, 2022): 1–8, https://doi.org/10.17509/ijotis.v3i1.43182.

[14] Ronal Watrianthos et al., "Research on Vocational Education in Indonesia: A Bibliometric Analysis," *JTEV (Jurnal Teknik Elektro Dan Vokasional)* 8, no. 2 (June 18, 2022): 187, https://doi.org/10.24036/jtev.v8i2.117045.

[15] Ni Wayan Surya Mahayanti et al., "The Trends of Peace Education Research in Indonesia: A Bibliometric Analysis Aligned with Quality of Education," *Journal of Lifestyle and SDGs Review* 5, no. 2 (January 17, 2025): e02571, https://doi.org/10.47172/2965-730X.SDGsReview.v5.n02.pe02571.

[16] Wigati Wigati, "Bibliometric Analysis of Machine Learning on Development Research for Education in Indonesia," *Jurnal Pendidikan (Teori Dan Praktik)* 8, no. 1 (May 19, 2023): 29–36, https://doi.org/10.26740/jp.v8n1.p29-36.

[17] Diaz Ilyasa, Yunus Winoto, and Evi Nursanti Rukmana, "Bibliometric Analysis of Digital Library in Indonesia 2014-2024 Using Biblioshiny Bibliometrix," *Berkala Ilmu Perpustakaan Dan Informasi* 21, no. 1 (June 19, 2025): 77–92, https://doi.org/10.22146/bip.v21i1.16158; Kamaludin (Mr.) Kamaludin and Abdurakhman Prasetyadi, "Two Decades of Bibliometric Research in Indonesia," *THE LIGHT : Journal of Librarianship and Information Science* 3, no. 1 (June 27, 2023): 32–43, https://doi.org/10.20414/light.v3i1.7034.

leading authors and institutions along with their collaboration networks, and (4) examine how thematic structures and research priorities have shifted over the years.

This research adds to the expanding field of meta-research in educational technology by providing an evidence-based synthesis of over ten years of scholarly publications originating from Indonesia. In doing so, it fills a critical gap left by previous studies, which either focused on limited periods, specific educational levels, or non-Scopus data sources. The findings, which highlight emerging themes, underexplored areas, and potential avenues for future research, are expected to serve as a strategic reference for researchers, policymakers, and educational practitioners in shaping the future of digital education in Indonesia.

METHOD

Research Design

This study employed a quantitative bibliometric research design to map and analyze scholarly publications' development, thematic structure, and intellectual patterns related to the digital transformation of education in Indonesia. Bibliometric analysis is a well-established method in scientific research evaluation, allowing for the systematic examination of large volumes of academic literature using statistical and network-based techniques.[18] It is particularly effective in identifying publication trends, influential authors and institutions, key research themes, and collaborative structures over time.[19] The design of this study was descriptive and exploratory, aiming to answer questions about "what," "when," and "who" within the context of digital education research in Indonesia. The focus was quantifying publication outputs, mapping thematic developments, and visualizing the relationships between authors, keywords, and institutions. The analysis covered publications from 2012 to May 31, 2025, representing more than a decade of scholarly activity in the field.

Data Source and Search Strategy

The bibliographic data utilized in this study were obtained from the Scopus database, recognized as one of the most extensive and reputable sources of peer-reviewed abstracts and citations.[20] Scopus was chosen for its broad multidisciplinary coverage, rigorous selection standards, and its suitability for bibliometric analysis.[21] The search was conducted on May-

[18] Ivan Zupic and Tomaž Čater, "Bibliometric Methods in Management and Organization," *Organizational Research Methods* 18, no. 3 (July 22, 2015): 429–72, https://doi.org/10.1177/1094428114562629; Ole Ellegaard and Johan A. Wallin, "The Bibliometric Analysis of Scholarly Production: How Great Is the Impact?," *Scientometrics* 105, no. 3 (December 28, 2015): 1809–31, https://doi.org/10.1007/s11192-015-1645-z; Naveen Donthu et al., "How to Conduct a Bibliometric Analysis: An Overview and Guidelines," *Journal of Business Research* 133 (September 2021): 285–96, https://doi.org/10.1016/j.jbusres.2021.04.070.

[19] Ellegaard and Wallin, "The Bibliometric Analysis of Scholarly Production: How Great Is the Impact?"; José A. Moral-Muñoz et al., "Software Tools for Conducting Bibliometric Analysis in Science: An up-to-Date Review," *El Profesional de La Información* 29, no. 1 (January 19, 2020), https://doi.org/10.3145/epi.2020.ene.03; Shashidhar Kaparthi, "A Bibliometric Analysis," *Journal of Decision Systems* 14, no. 1–2 (January 18, 2005): 157–77, https://doi.org/10.3166/jds.14.157-177; Asim F. Choudhri et al., "Understanding Bibliometric Parameters and Analysis," *RadioGraphics* 35, no. 3 (May 2015): 736–46, https://doi.org/10.1148/rg.2015140036.

[20] Muhammad Aizri Fadillah et al., "Bibliometric Mapping of Data Science in Education: Trends, Benefits, Challenges, and Future Directions," *Social Sciences & Humanities Open* 11 (2025): 101600, https://doi.org/10.1016/j.ssaho.2025.101600.

[21] Massimo Aria et al., "OpenalexR: An R-Tool for Collecting Bibliometric Data from OpenAlex," *The R Journal* 15, no. 4 (April 11, 2024): 167–80, https://doi.org/10.32614/RJ-2023-089.

June, 2025, to identify scholarly works focusing on the digital transformation of education in Indonesia. The search strategy was developed using a combination of controlled vocabulary and keyword variations to maximize thematic relevance and recall. The following search query was used: *TITLE-ABS-KEY ("digital education" OR "e-learning" OR "online learning" OR "blended learning" OR "distance learning" OR "technology-enhanced learning") AND TITLE-ABS-KEY (Indonesia)*. This query was designed to capture all journal articles on digital learning and education technologies, specifically in Indonesian.

The search was restricted using specific criteria to ensure consistency, relevance, and analytical rigor. Only journal articles were included, while other document types such as conference proceedings, reviews, book chapters, and editorials were excluded to maintain a focused analysis on peer-reviewed scholarly contributions. The language was limited to English to ensure broader international visibility and standardization across metadata fields. The publication time frame was set between January 1, 2012, and May 31, 2025, covering over a decade of research activity, including early-access articles from 2025. The dataset was drawn exclusively from the Scopus Core Collection, known for its comprehensive indexing of high-impact journals. Additionally, the author name format was set to FullName during export to ensure accurate identification and disambiguation of authors in the bibliometric analysis.

The initial query yielded 1,682 documents, published in 347 unique journal sources, and authored by 5,143 individuals. The dataset was exported in CSV format and subsequently imported into the Biblioshiny interface (R-based Bibliometrix package) for data cleaning, filtering, and analysis.[22] To improve the analytical focus and thematic coherence, the dataset was further refined using Bradford's Law of Scattering, a bibliometric principle used to identify the most productive sources in a field. Only documents falling within the core zone and zone 2 of the source distribution were retained, resulting in a final dataset of 1,131 articles, published across 66 journal sources, and authored by 3,529 researchers during the 2012–2025 period.

Inclusion and Exclusion Criteria

The study focused exclusively on peer-reviewed journal articles indexed in the Scopus Core Collection and published between January 1, 2012, and May 31, 2025. Articles had to be written in English and thematically focused on digital learning, e-learning, online education, blended learning, or technology-enhanced learning within the Indonesian educational context. Furthermore, to concentrate the analysis on sources with the highest scientific productivity and relevance, only documents published in journals falling within the core zone and zone 2—as defined by Bradford's Law of Scattering—were retained.[23]

[22] Massimo Aria and Corrado Cuccurullo, "Bibliometrix : An R-Tool for Comprehensive Science Mapping Analysis," *Journal of Informetrics* 11, no. 4 (November 2017): 959–75, https://doi.org/10.1016/j.joi.2017.08.007.

[23] B.C. VICKERY, "BRADFORD'S LAW OF SCATTERING," *Journal of Documentation* 4, no. 3 (April 1, 1948): 198–203, https://doi.org/10.1108/eb026133; Nidhi Desai, Laura Veras, and Ankush Gosain, "Using Bradford's Law of Scattering to Identify the Core Journals of Pediatric Surgery," *Journal of Surgical Research* 229 (September 2018): 90–95, https://doi.org/10.1016/j.jss.2018.03.062.

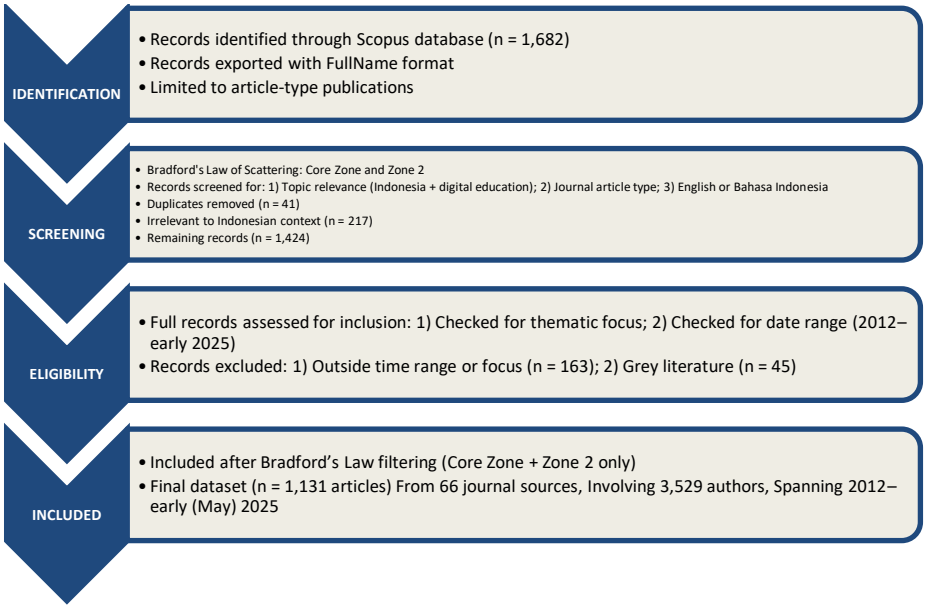


Figure 1. PRISMA-based flow diagram of the document selection process.[24]

Articles were excluded if they were not journal publications (e.g., conference proceedings, book chapters, reviews, or editorials), were not explicitly related to the digital transformation of education in Indonesia, or were duplicate entries or retracted publications. Publications from sources classified within Bradford's zone 3 were also excluded, as they represent peripheral contributions with limited impact on the core structure of the research field.[25] This filtering process allowed the study to focus on a concentrated and high-quality subset of literature that accurately reflects the development of digital education research in Indonesia.[26]

Data Validation

A systematic data validation process was conducted before analysis to ensure the reliability and validity of the bibliometric dataset.[27] First, duplicate records were identified and removed using unique Scopus identifiers to prevent publication and authorship count distortion.[28] Second, manual screening of titles, abstracts, and source information was

[24] Matthew J. Page et al., "The PRISMA 2020 Statement: An Updated Guideline for Reporting Systematic Reviews," *Systematic Reviews* 10, no. 1 (December 29, 2021): 89, https://doi.org/10.1186/s13643-021-01626-4; Catrin Sohrabi et al., "PRISMA 2020 Statement: What's New and the Importance of Reporting Guidelines," *International Journal of Surgery* 88 (April 2021): 105918, https://doi.org/10.1016/j.ijsu.2021.105918; Hai Vu-Ngoc et al., "Quality of Flow Diagram in Systematic Review and/or Meta-Analysis," ed. David Moher, *PLOS ONE* 13, no. 6 (June 27, 2018): e0195955, https://doi.org/10.1371/journal.pone.0195955.

[25] Desai, Veras, and Gosain, "Using Bradford's Law of Scattering to Identify the Core Journals of Pediatric Surgery."

[26] Gyanajeet Yumnam and Ch. Ibohal Singh, "An Application of Bradford's Law of Scattering and Leimkuhler Model: Identification of the Core Journals of India Cancer Research Productivity," *Science & Technology Libraries* 43, no. 2 (April 2, 2024): 188–201, https://doi.org/10.1080/0194262X.2023.2237997.

[27] Weng Marc Lim, Satish Kumar, and Naveen Donthu, "How to Combine and Clean Bibliometric Data and Use Bibliometric Tools Synergistically: Guidelines Using Metaverse Research," *Journal of Business Research* 182 (September 2024): 114760, https://doi.org/10.1016/j.jbusres.2024.114760.

[28] Mehmet Ali Koseoglu, Hasan Evrim Arici, and Nagihan Cakmakoglu Arici, "Does Data Curation Matter in Citation and Co-Citation Analysis? Evidence from a Top Service Journal," *COLLNET Journal of Scientometrics and Information Management* 17, no. 2 (2023): 269–87, https://doi.org/10.47974/CJSIM-2020-0011; Wirapong Chansanam and Chunqiu Li, "KKU-

performed to confirm each article's thematic and geographic relevance to the digital transformation of education in Indonesia. This step helped eliminate studies that included "Indonesia" as a keyword or in affiliation metadata but were not substantively related to the Indonesian educational context. Third, a keyword normalization procedure was applied to address inconsistencies in terminology.[29] Synonymous or semantically similar terms (e.g., “e-learning” vs. “electronic learning”; “online learning” vs. “distance learning”) were standardized to improve the accuracy of co-word analysis and thematic clustering. This step minimized fragmentation and enhanced the interpretability of the thematic maps.

To enhance the relevance and focus of the dataset, each journal source was evaluated using Bradford's Law of Scattering, and only articles published in journals within the core zone and zone 2 were retained.[30] This refinement ensured the dataset represented the field's most productive and thematically central publications.[31] These validation procedures established a rigorous and coherent dataset suitable for high-quality bibliometric analysis.[32]

Ethical Considerations

This study is based entirely on secondary data derived from the Scopus database and involves no human participants, personal data, or intervention. As such, it does not require ethical approval from an institutional review board. Responsible research practices were conducted, and all data used were publicly available and cited appropriately. The authors affirm that the research was carried out objectively and transparently. There are no known financial or non-financial conflicts of interest that could have influenced the design, execution, interpretation, or reporting of this study.

DISCUSSION

Result

Publication Output

The bibliometric analysis demonstrates a marked increase in scholarly output related to the digital transformation of education in Indonesia between 2012 and 2025. This upward trend reflects the dynamic and rapidly evolving nature of research in this field over 13 years. The dataset comprises 1,131 Scopus-indexed journal articles, all of which are peer-reviewed, indicating a clear focus on scholarly rigor and empirical contribution. Including early-access

BiblioMerge: A Novel Tool for Multi-Database Integration in Bibliometric Analysis,” *Iberoamerican Journal of Science Measurement and Communication* 5, no. 1 (February 1, 2025): 1–16, https://doi.org/10.47909/ijsmc.157.

[29] Lim, Kumar, and Donthu, “How to Combine and Clean Bibliometric Data and Use Bibliometric Tools Synergistically: Guidelines Using Metaverse Research.”

[30] VICKERY, “BRADFORD’S LAW OF SCATTERING”; Charlotte E Nash-Stewart, Lisa M Kruesi, and Chris B Del Mar, “Does Bradford’s Law of Scattering Predict the Size of the Literature in Cochrane Reviews?,” *Journal of the Medical Library Association : JMLA* 100, no. 2 (April 2012): 135–38, https://doi.org/10.3163/1536-5050.100.2.013; Desai, Veras, and Gosain, “Using Bradford’s Law of Scattering to Identify the Core Journals of Pediatric Surgery”; Yumnam and Singh, “An Application of Bradford’s Law of Scattering and Leimkuhler Model: Identification of the Core Journals of India Cancer Research Productivity.”

[31] I. K. Ravichandra Rao, “An Analysis of Bradford Multipliers and a Model to Explain Law of Scattering,” *Scientometrics* 41, no. 1–2 (January 1998): 93–100, https://doi.org/10.1007/BF02457970.

[32] Yumnam and Singh, “An Application of Bradford’s Law of Scattering and Leimkuhler Model: Identification of the Core Journals of India Cancer Research Productivity.”

publications from 2025 ensures that the dataset captures the most current developments in the field.

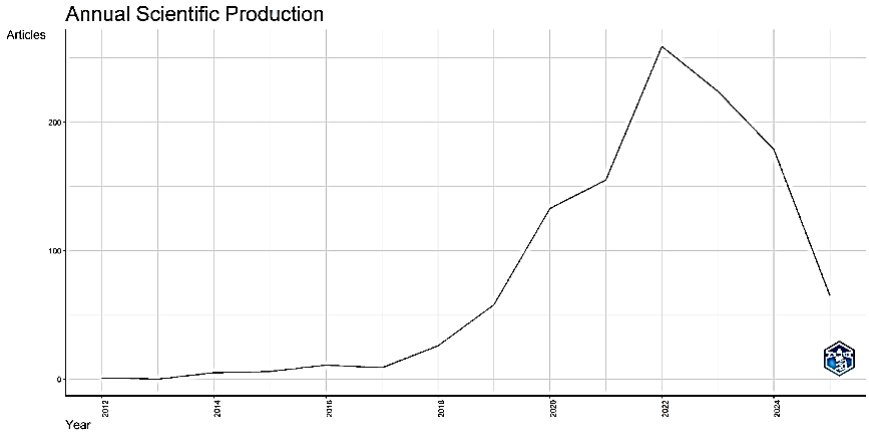


Figure 2. Number of articles published in Scopus on the digital transformation of education in Indonesia between 2012 and early 2025. (*source: Biblioshiny analysis results*)[33]

The annual distribution of publications reveals a gradual rise in output during the early years, beginning with just one article in 2012 and none in 2013. A modest increase occurred in subsequent years, with five articles published in 2014, six in 2015, and a further rise to 11 and 9 articles in 2016 and 2017, respectively. A significant turning point emerged in 2018, with 26 articles published—more than doubling the previous year's output. This upward momentum continued in 2019 with 58 publications, suggesting growing recognition of digital education as a critical area of academic inquiry.

The most notable surge in publication volume occurred in 2020, with 133 articles, coinciding with the onset of the COVID-19 pandemic. This sharp increase likely reflects an urgent shift toward digital learning modalities and the need for rapid pedagogical adaptation, which catalyzed scholarly interest. The trend continued in 2021 with 155 publications and peaked in 2022, reaching 259 articles—the highest volume in the entire dataset. This peak aligns with the consolidation of digital transformation strategies within Indonesian educational institutions.

Although publication numbers slightly declined in 2023 (224 articles) and 2024 (179 articles), they remained significantly above pre-pandemic levels, indicating a sustained scholarly commitment to digital education research. As of January 2025, 65 articles had already been published, pointing to a potentially strong annual output by the year's end.

From a broader perspective, the field exhibits a Compound Annual Growth Rate (CAGR) of 37.87%, underscoring a robust and sustained increase in academic productivity. This growth is likely driven by several interrelated factors: the national push for digital learning reform under initiatives such as *Merdeka Belajar*, increased availability of digital infrastructure, global technological shifts, and the academic response to pandemic-induced

[33] Aria and Cuccurullo, "Bibliometrix : An R-Tool for Comprehensive Science Mapping Analysis."

disruptions. The average age of documents in the dataset is 3.11 years, suggesting a relatively recent and still-evolving body of literature. Meanwhile, an average citation rate of 8.867 per document and 48,937 references reflect the field's intellectual maturity and interconnectedness.

Authors and Institutions

Individual authors' and institutions' productivity and scholarly influence provide a crucial perspective on developing and leading digital education research in Indonesia. Based on the analysis of 1,131 Scopus-indexed journal articles published between 2012 and early 2025, 3,529 unique authors contributed to the field, with an average of 3.93 co-authors per article. This indicates a strong culture of academic collaboration, consistent with trends observed in interdisciplinary and technology-enhanced research domains. Furthermore, 16.71% of all publications involved international co-authorship, reflecting a modest but growing level of global research integration.

The temporal analysis of author productivity, as visualized through the Authors' Production Over Time plot, reveals that most of the most productive authors began contributing actively to this field around 2018. While some have demonstrated sustained productivity over multiple years, others show brief but intensive periods of scholarly output. Citation impact also varies significantly, with some publications receiving high visibility within the academic community, as indicated by total citations per year (TC/year). In contrast, others remain less cited but still contribute to the thematic diversity of the field.

Among the top contributors, Harry B. Santoso has maintained an active research trajectory from 2016 to 2024. His most cited work, "Measuring User Experience of the Student-Centered E-Learning Environment" (2016), remains influential in shaping usability and learner experience discussions.[34] Although his more recent works, such as "Lecturer Readiness for Online Classes During the Pandemic: A Survey Research" (2021), received comparatively fewer citations, he continues to engage with contemporary issues in digital education.[35]

I. Kadek Suartama is another prolific contributor, with consistent output between 2019 and 2024. His notable publications include "Development of an Instructional Design Model for Mobile Blended Learning in Higher Education" (2019)[36] and "Student Engagement and Academic Achievement: The Effect of Gamification on Case and Project-Based Online Learning" (2024)[37], which collectively highlight his emphasis on instructional design and learner motivation. Dwi Sulisworo, with a shorter publication window (2020–2021), made a

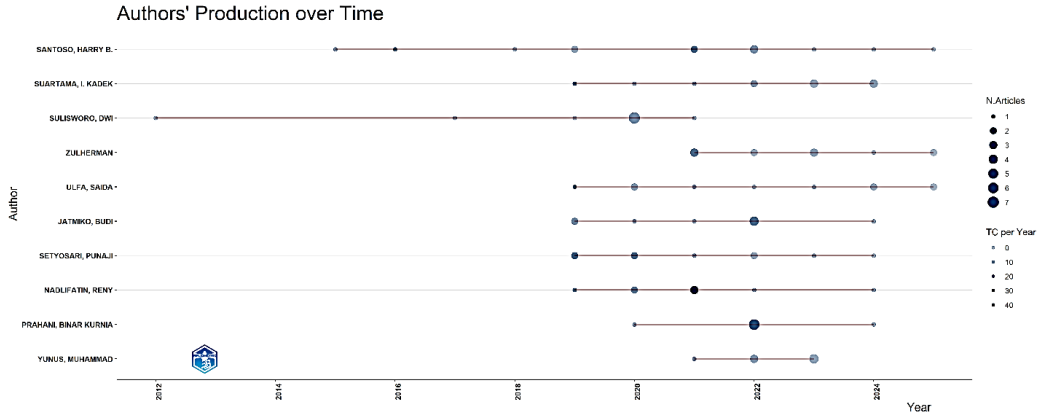
[34] Harry Santoso et al., "Measuring User Experience of the Student-Centered e-Learning Environment," *The Journal of Educators Online* 13, no. 1 (January 2016): 1–79, https://doi.org/10.9743/JEO.2016.1.5.

[35] Kasiyah Junus et al., "Lecturer Readiness for Online Classes during the Pandemic: A Survey Research," *Education Sciences* 11, no. 3 (March 22, 2021): 139, https://doi.org/10.3390/educsci11030139.

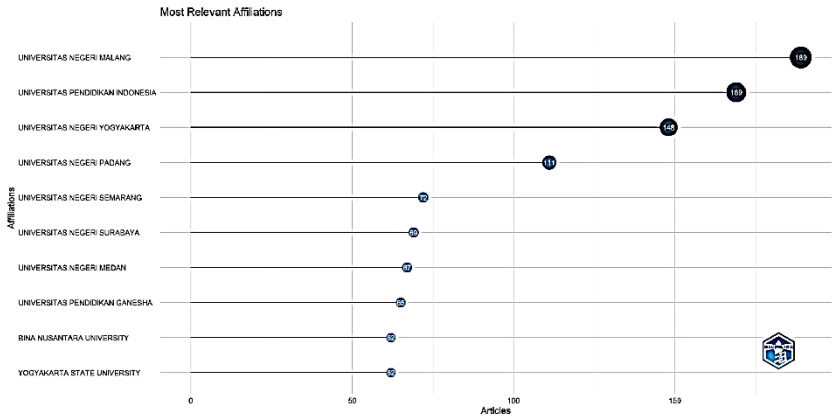
[36] I Kadek Suartama et al., "Development of an Instructional Design Model for Mobile Blended Learning in Higher Education," *International Journal of Emerging Technologies in Learning (IJET)* 14, no. 16 (August 29, 2019): 4, https://doi.org/10.3991/ijet.v14i16.10633.

[37] I Kadek Suartama et al., "Student Engagement and Academic Achievement: The Effect of Gamification on Case and Project-Based Online Learning," *Journal of Education and Learning (EduLearn)* 18, no. 3 (August 1, 2024): 968–82, https://doi.org/10.11591/edulearn.v18i3.21349.

substantial impact with "The Impact of the Use of STEM Education Approach on the Blended Learning to Improve Students' Critical Thinking Skills" (2020),[38] Reflecting growing interest in integrative pedagogical models.



(a)



(b)

Figure 3. Diagram (a) shows the top 10 most productive authors who published articles on the topic of digital transformation of education in Indonesia; (b) Top 10 most productive affiliations in publishing articles on the topic of digital transformation of education in Indonesia between 2012 and 2025. (*source: Biblioshiny analysis results*)[39]

Other influential authors include Zulherman, whose work between 2021 and 2023—particularly "Factor of Zoom Cloud Meetings: Technology Adoption in the Pandemic of COVID-19" (2021)—captured the sudden transition to virtual learning environments.[40] Saida Ulfa (2019–2021) and Punaji Setyosari (2019–2021) contributed significantly to mobile blended

[38] Suji Ardianti et al., "The Impact of the Use of STEM Education Approach on the Blended Learning to Improve Students' Critical Thinking Skills," *Universal Journal of Educational Research* 8, no. 3B (March 2020): 24–32, https://doi.org/10.13189/ujer.2020.081503.

[39] Aria and Cuccurullo.

[40] Zulherman Zulherman et al., "Factor of Zoom Cloud Meetings: Technology Adoption in the Pandemic of COVID-19," *International Journal of Evaluation and Research in Education (IJERE)* 10, no. 3 (September 1, 2021): 816, https://doi.org/10.11591/ijere.v10i3.21726.

learning research, including the foundational 2019 study on instructional design that remains frequently cited.[41] Budi Jatmiko achieved peak scholarly impact in 2022 with his co-authored article "Artificial Intelligence in Education Research During the Last Ten Years: A Review and Bibliometric Study," highlighting a growing interest in AI-driven educational insights.[42] Similarly, Binar Kurnia Prahani[43] and Reny Nadlifatin[44] Provided key contributions in AI integration and e-learning acceptance, respectively. Lastly, Muhammad Yunus, active from 2021 to 2023, addressed comparisons between ubiquitous and electronic learning concerning student engagement and self-regulated learning strategies.

Institutional contributions further underscore the prominence of Indonesian public universities in driving national research on digital education. Universitas Negeri Malang leads with 189 articles, followed by Universitas Pendidikan Indonesia (169 articles) and Universitas Negeri Yogyakarta (148 articles). These teacher-training institutions are national hubs for pedagogical innovation and educational technology research. Universitas Negeri Padang (111 articles), Universitas Negeri Semarang (72), and Universitas Negeri Surabaya (69) also demonstrate strong publication records, reinforcing the critical role of state universities in promoting digital transformation in education.

Universitas Negeri Medan (67 articles) and Universitas Pendidikan Ganesha (65 articles) reflect growing scholarly engagement from institutions located outside Java, indicating geographic diversification of research activity. Among private institutions, Bina Nusantara University is the most productive, contributing 62 publications. Notably, Yogyakarta State University—also reporting 62 publications—further reinforces Yogyakarta's status as a key center of educational research and development.

These author and institutional productivity patterns reveal a vibrant and expanding scholarly ecosystem. The increasing contributions from both public and private institutions and the emergence of new authorial voices suggest a healthy and maturing research field well-positioned to support national and regional educational priorities through evidence-based innovation.

Collaboration Network

The co-authorship and institutional collaboration analysis provides valuable insights into the structural patterns and dynamics of scholarly interaction within the field of digital education research in Indonesia. As of early 2025, the 1,131 documents analyzed were authored by 3,529 individuals, reflecting a broad and diverse academic community. The

[41] Suartama et al., "Development of an Instructional Design Model for Mobile Blended Learning in Higher Education."
[42] Binar Kurnia Prahani et al., "Artificial Intelligence in Education Research During The Last Ten Years: A Review and Bibliometric Study," *International Journal of Emerging Technologies in Learning (IJET)* 17, no. 08 (April 26, 2022): 169–88, https://doi.org/10.3991/ijet.v17i08.29833.
[43] Prahani et al.; B K Prahani et al., "Trend of Mobile, Web, E-Learning Research in 2002-2021: Contribution to Physics Learning," *World Journal on Educational Technology: Current Issues* 14, no. 5 (2022): 1434–51, https://doi.org/10.18844/wjet.v14i5.7416.
[44] Ardvin Kester S Ong et al., "Students' Preference Analysis on Online Learning Attributes in Industrial Engineering Education during the COVID-19 Pandemic: A Conjoint Analysis Approach for Sustainable Industrial Engineers," *Sustainability* 13, no. 15 (July 26, 2021): 8339, https://doi.org/10.3390/su13158339; Yogi Tri Prasetyo et al., "Determining Factors Affecting Acceptance of E-Learning Platforms during the COVID-19 Pandemic: Integrating Extended Technology Acceptance Model and DeLone & McLean IS Success Model," *Sustainability* 13, no. 15 (July 27, 2021): 8365, https://doi.org/10.3390/su13158365.

average number of co-authors per document was 3.93, underscoring the collaborative nature of the field. Furthermore, the Collaboration Index (CI) for multi-authored documents stands at 4.04, indicating a tendency toward moderately sized research teams rather than isolated or single-author publications.

From an international perspective, 189 of the 1,131 documents (16.71%) involved at least one co-author affiliated with a non-Indonesian institution. Although this proportion suggests that most research remains domestically focused, it also indicates an emerging trend of global engagement, particularly in studies that intersect with broader themes such as online learning technologies, e-learning platforms, and artificial intelligence in education. Collaborative links with countries such as Malaysia, Australia, the United States, and the Netherlands were especially prominent, reflecting regional proximity or historical academic partnerships.

Institutional collaboration networks within Indonesia reveal several key clusters of co-authorship. The strongest internal linkages are among top-producing institutions such as Universitas Negeri Malang, Universitas Pendidikan Indonesia, and Universitas Negeri Yogyakarta. These institutions frequently co-author with regional counterparts and with each other, forming a core network of digital education scholarship. Notably, multi-institutional authorship is obvious in high-output articles published during the pandemic (2020–2022), suggesting that crisis-driven research mobilized a more unified academic response.

Thematic collaboration mapping further indicates that author groups cluster around specific subtopics—such as mobile learning, gamification, or digital assessment—forming semi-specialized knowledge communities. Authors involved in highly cited publications on e-learning and instructional design, for example, tend to co-author repeatedly with peers from their institutions or long-standing collaborators, reinforcing patterns of academic proximity and sustained intellectual partnerships.

While inter-institutional collaboration at the national level appears robust, the relatively modest proportion of internationally co-authored papers points to a potential area for strategic development. Increased engagement in global research networks could further elevate Indonesian scholarship's international visibility and impact in digital education. Encouraging transnational collaboration—particularly through funded joint research, co-supervision of graduate students, and regional consortia—may offer pathways to expand the thematic scope and strengthen the scientific contribution of Indonesia to global educational discourse.

The collaboration network in this field is characterized by a strong national structure with growing international outreach. The current patterns suggest a solid foundation for domestic research productivity and an opportunity to expand global academic integration through more deliberate and strategic partnerships.

Keyword Trends and Thematic Focus

Keyword analysis offers valuable insights into the thematic structure and evolving priorities of digital education research in Indonesia. This study identified 739 Keywords Plus and 2,643 Author Keywords from 1,131 Scopus-indexed journal articles, indicating a high level

of lexical richness and conceptual diversity. The most frequently occurring Author Keywords reflect the dominant discourse and help illuminate recurring research concerns over time.

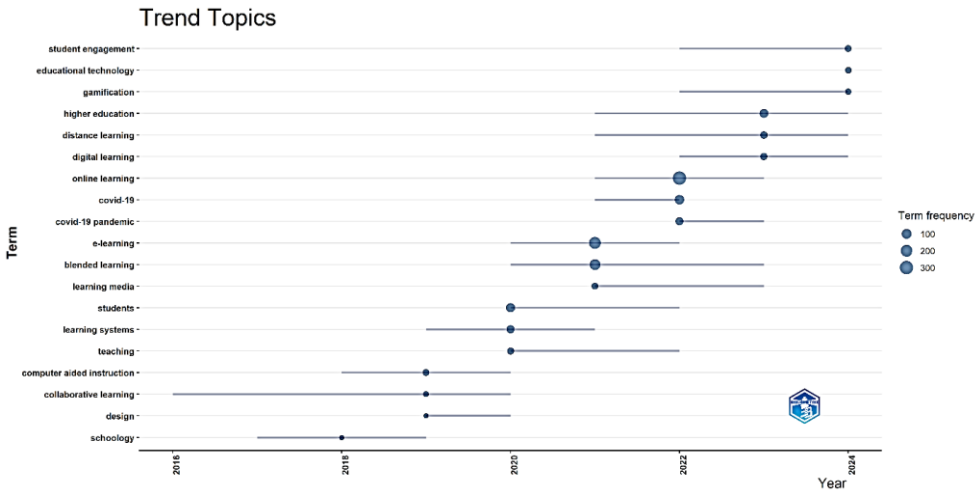


Figure 4. The diagram shows the 19 most relevant topics related to digital education in Indonesia during the 2016-2024 period. (*source: Biblioshiny analysis results*)[45]

The ten most frequently used keywords during the 2012–2025 period are as follows: “online learning” (304 occurrences), “e-learning” (212), “blended learning” (143), “COVID-19” (97), “students” (73), “higher education” (68), “learning systems” (49), “COVID-19 pandemic” (44), “Indonesia” (38), and “learning management system” (36). The prevalence of “online learning” as the most dominant keyword highlights the centrality of remote and internet-based instructional modalities in the Indonesian context, especially during and after the COVID-19 pandemic. This finding aligns with global trends that reflect an educational shift toward virtual platforms as a response to school closures and social distancing mandates.

The term “e-learning” also appears prominently, suggesting continued scholarly engagement with structured digital education platforms that predate the pandemic but have since evolved in sophistication and scale. “Blended learning” occupies the third position, indicating increasing attention to hybrid instructional models that combine face-to-face and digital components. The frequent co-occurrence of “COVID-19” and “COVID-19 pandemic” as keywords reflects the unprecedented impact of the health crisis on educational delivery and its subsequent prominence in research agendas during 2020–2022.

The keyword “students” ranks fifth, suggesting that much of the research is learner-centered, focusing on engagement, performance, and experience in digital environments. Similarly, “higher education” appears as a recurring context in which digital transformation is studied, confirming that universities and tertiary institutions have been at the forefront of adopting and experimenting with digital pedagogies in Indonesia.

[45] Aria and Cuccurullo, “Bibliometrix : An R-Tool for Comprehensive Science Mapping Analysis.”

Other high-frequency terms such as “learning systems” and “learning management system” (LMS) underscore the technical backbone supporting digital learning implementations, particularly during the rapid transition to online instruction. The appearance of “Indonesia” as a keyword, while expected given the scope of this study, also highlights a localized framing in the literature, distinguishing it from globally generalized research.

Thematic clustering based on keyword co-occurrence revealed three dominant conceptual clusters: (1) instructional design and pedagogical strategies, (2) technology platforms and adoption, and (3) digital competencies and literacy. The first cluster includes terms like “blended learning,” “mobile learning,” and “instructional design,” indicating a sustained interest in curriculum development and learner engagement. The second cluster, which includes keywords like “learning management system,” “Zoom,” and “Google Classroom,” reflects the rapid deployment and adaptation of digital tools in educational contexts. The third cluster, increasingly visible in recent years, revolves around concepts such as “digital literacy,” “student self-efficacy,” and “21st-century skills,” signaling a broader shift toward equipping learners with the competencies required for lifelong digital learning.

Overall, the keyword analysis indicates a research field that is conceptually diverse, technologically responsive, and increasingly focused on pedagogical innovation, student agency, and systemic transformation. The progression in keyword trends from general topics to more nuanced, skill-based, and impact-oriented terms reflects a maturing field adapting to evolving educational demands and technological landscapes.

Strategic Thematic Mapping

Strategic thematic mapping provides an in-depth understanding of the intellectual structure and developmental maturity of research themes in Indonesia's digital transformation of education. This analysis relies on two core dimensions: centrality, which measures the degree of interaction between a theme and other themes (i.e., its relevance within the field), and density, which assesses the internal strength and development of a theme. These dimensions categorize themes into four quadrants: motor themes (high centrality and density), basic themes (high centrality, low density), niche themes (low centrality, high density), and emerging or declining themes (low centrality and density).[46]

The strategic diagram constructed from the dataset positions "e-learning" in the motor themes quadrant, indicating that it is a well-developed and highly connected area of research. Its internal consistency and central relevance make it foundational to the field. The cluster surrounding "e-learning" also includes terms such as students and learning systems, further reinforcing its position as a robust and widely integrated research theme. Several highly cited articles published in the International Journal of Emerging Technologies in Learning—

[46] Everton Cruz da Silva et al., “The Importance of Traditional Communities in Biodiversity Conservation,” *Biodiversity and Conservation* 34, no. 2 (February 26, 2025): 685–714, https://doi.org/10.1007/s10531-024-02999-3.

including those by Ridwan (2020),[47] Arifianto M.L. (2021),[48] and Safiah I. (2023)[49]—serve as central contributions that sustain this thematic cluster.

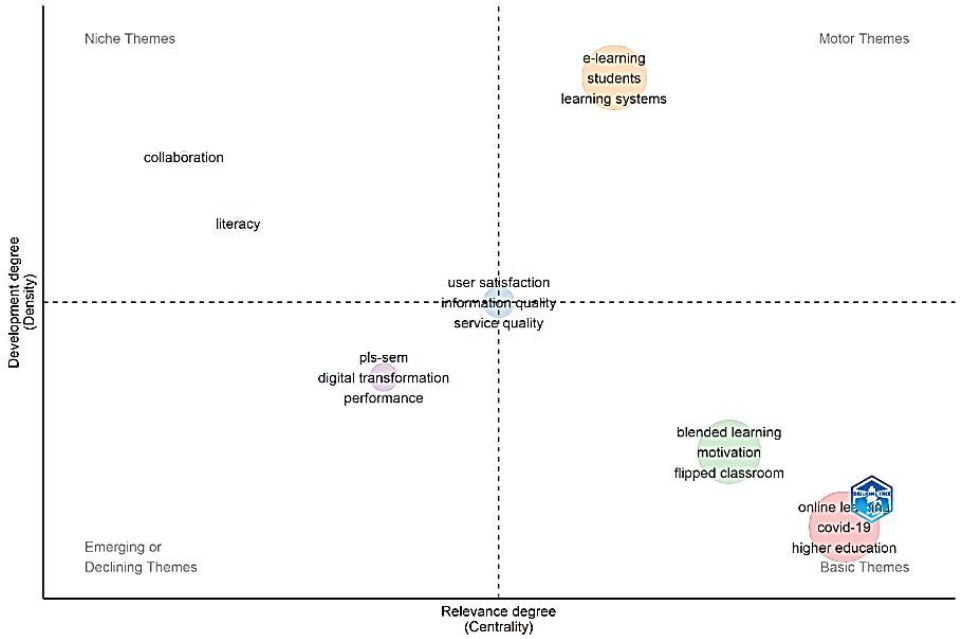


Figure 5. Strategic Thematic Map of Digital Education Research in Indonesia (2012–2025). (*source: Biblioshiny analysis results*)[50]

The terms "Online learning" and "blended learning" appear in the basic themes quadrant, suggesting that while these topics are central to ongoing discourse, they are still developing in terms of internal conceptual and methodological coherence. The presence of articles by Widiyanto A. (2023),[51] Sari D.P. (2022),[52] and Pradana R.P. (2024)[53] points to growing scholarly attention toward these modes of delivery, especially in the context of

[47] R D Mahande and E S Rahman, "A PLS-SEM Approach to Understand ARCS, McClellands, and SDT for the Motivational Design of Online Learning System Usage in Higher Education," *Turkish Online Journal of Distance Education* 23, no. 1 (2022): 97–112, https://www.scopus.com/inward/record.uri?eid=2-s2.0-85123600736&partnerID=40&md5=d767f39b83348893d1a01d3e934c6fa4.

[48] Muhammad Lukman Arifianto and Iqbal Fathi Izzudin, "Students' Acceptance of Discord as an Alternative Online Learning Media," *International Journal of Emerging Technologies in Learning (IJET)* 16, no. 20 (October 25, 2021): 179, https://doi.org/10.3991/ijet.v16i20.22917.

[49] Intan Safiah et al., "OLMs Development to Improve Students' Ability to Produce Learning Media," *International Journal of Emerging Technologies in Learning (IJET)* 18, no. 05 (March 7, 2023): 4–18, https://doi.org/10.3991/ijet.v18i05.28437.

[50] Aria and Cuccurullo, "Bibliometrix : An R-Tool for Comprehensive Science Mapping Analysis."

[51] Andi Widiyanto et al., "Influence of Blockchain Implementation for Virtual Meetings at Home Learning Indonesia," *International Journal of Emerging Technologies in Learning (IJET)* 18, no. 06 (March 21, 2023): 220–27, https://doi.org/10.3991/ijet.v18i06.37255.

[52] Dwi Puspita Sari et al., "Higher Education Student Satisfaction with Online Learning: The Role of Teaching Material and Infrastructure," *International Journal of Information and Education Technology* 13, no. 8 (2023): 1273–83, https://doi.org/10.18178/ijiet.2023.13.8.1929.

[53] Syahrul Alam Suriazdin et al., "Technology Attractiveness and Its Impact on MOOC Continuance Intention," *International Journal of Emerging Technologies in Learning (IJET)* 17, no. 04 (February 28, 2022): 239–50, https://doi.org/10.3991/ijet.v17i04.28853.

higher education. In the same vein, studies by Sulisworo D. (2012),[54] Perguna L.A. (2021),[55] and Riyanto (2022)[56] contribute to the blended learning theme. Furthermore, an intersectional article by Syafryadin (2022)[57] on blended and online learning in applied linguistics illustrates the nuanced thematic overlap and disciplinary expansion in this area.

The niche themes quadrant includes “collaboration” and “literacy”, which, while internally well-developed, show limited external linkage to other themes. These clusters are supported by research published in a diverse range of journals, including the International Journal of Instruction, Jurnal Pendidikan IPA Indonesia, and Social Sciences & Humanities Open for collaboration-related studies, and Sustainability, Journal of Social Studies Education Research, and Journal of Language Teaching and Research for literacy-focused work. Key contributors to these clusters include Purwandari E.P. (2022),[58] Haryono H.E. (2024),[59] and Ika Sari G. (2024)[60] in collaboration studies, and Lubis M. (2022),[61] Rustan A.S. (2021),[62] and Atmazaki (2023)[63] in literacy-focused research.

The emerging or declining themes quadrant contains the "PLS-SEM" and "user satisfaction" clusters. These themes demonstrate low centrality and density, suggesting that they are either new and still developing or have seen a decline in scholarly attention. The PLS-SEM cluster is represented by studies from Cenka Ban (2023),[64] Fadhilah F. (2023),[65] and Amin

[54] Dwi Sulisworo, “Designing the Online Collaborative Learning Using the Wikispaces,” *International Journal of Emerging Technologies in Learning (IJET)* 7, no. 1 (February 29, 2012): 58, https://doi.org/10.3991/ijet.v7i1.1863.

[55] Luhung Achmad Perguna, Netty Apriyanti, and Dedeh Kurniasih, “Alternative Online Learning Using Social Media as a Panacea,” *International Journal of Emerging Technologies in Learning (IJET)* 16, no. 07 (April 9, 2021): 257, https://doi.org/10.3991/ijet.v16i07.21209.

[56] Nurul Khotimah, Yatim Riyanto, and Bachtiar Syaiful Bachri, “Implementation of Blended Learning to Improve Motivation and Learning Outcomes of Pre-Service Early Childhood Teachers,” *Journal of Educational and Social Research* 12, no. 5 (September 2, 2022): 263, https://doi.org/10.36941/jesr-2022-0139.

[57] Syafryadin Syafryadin et al., “Teacher Readiness and Challenges in Creating Learner Autonomy in ICT-Based English Learning Activities,” *Indonesian Journal of Applied Linguistics* 11, no. 3 (January 31, 2022): 708–17, https://doi.org/10.17509/ijal.v11i3.34667.

[58] Endina Putri Purwandari, Kasiyah Junus, and Harry Budi Santoso, “Exploring E-Learning Community of Inquiry Framework for Engineering Education,” *International Journal of Instruction* 15, no. 1 (January 1, 2022): 619–32, https://doi.org/10.29333/iji.2022.15135a.

[59] Heny Ekawati Haryono et al., “E-Learning-Based Collaborative as an Effort to Reduce High School Students’ Misconceptions of Heat,” *Jurnal Pendidikan IPA Indonesia* 13, no. 4 (November 27, 2024): 538–50, https://doi.org/10.15294/e595yc53.

[60] R Hasibuan et al., “Implementing a Traditional Game to Stimulate Cognitive Skills during Online Learning: Early Childhood Education,” *International Journal of Early Childhood Learning* 29, no. 1 (2022): 25–39, https://doi.org/10.18848/2327-7939/CGP/v29i01/25-39.

[61] Fauzan Fauzan et al., “Lecturer’s Digital Literacy Ability in the Pandemic,” *Cypriot Journal of Educational Sciences* 17, no. 4 (April 30, 2022): 1130–42, https://doi.org/10.18844/cjes.v17i4.7122.

[62] A S Rustan, “Digital Communication and Social Media Interaction to Improve the Academic Quality of Islamic Higher Education Lecturers,” *Journal of Social Studies Education Research* 12, no. 4 (2021): 144–69, https://www.scopus.com/inward/record.uri?eid=2-s2.0-85124535495&partnerID=40&md5=7d765b6c004b1143a7cddb63c6d40e62.

[63] Yunisa Oktavia et al., “The Role of Blended Learning and Creative Problem-Solving in Scientific Article Writing: A Case Study in Higher Education,” *TEM Journal* 14, no. 2 (May 27, 2025): 1445–57, https://doi.org/10.18421/TEM142-45.

[64] Baginda Anggun Nan Cenka, Harry B Santoso, and Kasiyah Junus, “The Third Wave of Self-Regulated Learning’s Measurement and Intervention Tools: Designing ‘Diaria’ as a New Generation of Learning Diary,” *International Journal of Emerging Technologies in Learning (IJET)* 18, no. 09 (May 10, 2023): 216–42, https://doi.org/10.3991/ijet.v18i09.35605.

[65] Fadhilah Fadhilah and Muhammad Husin, “Student Readiness on Online Learning in Higher Education: An Empirical Study,” *International Journal of Instruction* 16, no. 3 (July 1, 2023): 489–504, https://doi.org/10.29333/iji.2023.16326a.

M. (2023),[66] which typically focus on quantitative modeling to examine relationships in digital learning environments. Similarly, the user satisfaction cluster includes contributions by Ohliati J. (2019),[67] Hidayatullah (2024),[68] and Rahayu N.S. (2023),[69] highlighting efforts to assess user experiences with digital platforms. However, their limited connectivity to broader themes may indicate a need for further conceptual integration.

The strategic mapping reveals a balanced thematic landscape that includes mature, influential topics and emerging areas that offer potential for further exploration. The central position of e-learning, online learning, and blended learning affirms their foundational status, while niche and emerging themes provide insight into the field's expanding boundaries and specialized applications. This structure highlights the coherence and diversity of Indonesia's digital education research, offering pathways for future inquiry and interdisciplinary collaboration.

Topic Evolution

The evolution of research topics over time provides a chronological perspective on how scholarly focus in digital education has transformed in response to pedagogical needs, technological advancements, and contextual factors in Indonesia. Based on the temporal analysis of author keywords and thematic clusters, four distinct periods are identified: 2012–2015, 2016–2019, 2020–2023, and 2024–2025. Each period reflects a shift in conceptual priorities, with earlier years focusing on foundational technologies and later years expanding into complex pedagogical frameworks and evaluative studies.

2012–2015 marks the foundational phase, in which core themes such as e-learning, collaborative learning, and computer-aided instruction emerged as motor themes. These topics formed the backbone of early digital education research in Indonesia, addressing how digital tools could support interaction, content delivery, and student engagement. The term "higher education" was a basic theme during this period, indicating its role as a primary context for digital experimentation and implementation. The limited number of publications suggests that while research was nascent, it was already centered on integrating technology into instructional models.

[66] Muhammad Amin, Abdul Muin Sibuea, and Bima Mustaqim, "The Effectiveness of Moodle among Engineering Education College Students in Indonesia," *International Journal of Evaluation and Research in Education (IJERE)* 12, no. 1 (March 1, 2023): 1, https://doi.org/10.11591/ijere.v12i1.23325.

[67] Jenny Ohliati and Bahtiar Saleh Abbas, "Measuring Students Satisfaction in Using Learning Management System," *International Journal of Emerging Technologies in Learning (IJET)* 14, no. 04 (February 27, 2019): 180, https://doi.org/10.3991/ijet.v14i04.9427.

[68] Rachmad Syarifudin Hidayatullah, Supardji Supardji, and I Wayan Susila, "Development of Digital Learning Simulators to Increase Vocational Students' Prior Knowledge," *TEM Journal* 13, no. 3 (August 27, 2024): 1981–88, https://doi.org/10.18421/TEM133-26.

[69] Neneng Sri Rahayu, Muhammad Hasan Dhiaullah, and Alvita Marsha, "Utilizing E-Learning and User Loyalty with User Satisfaction as Mediating Variable in Public Sector Context," *International Journal of Data and Network Science* 7, no. 3 (2023): 1341–48, https://doi.org/10.5267/j.ijdns.2023.4.004.

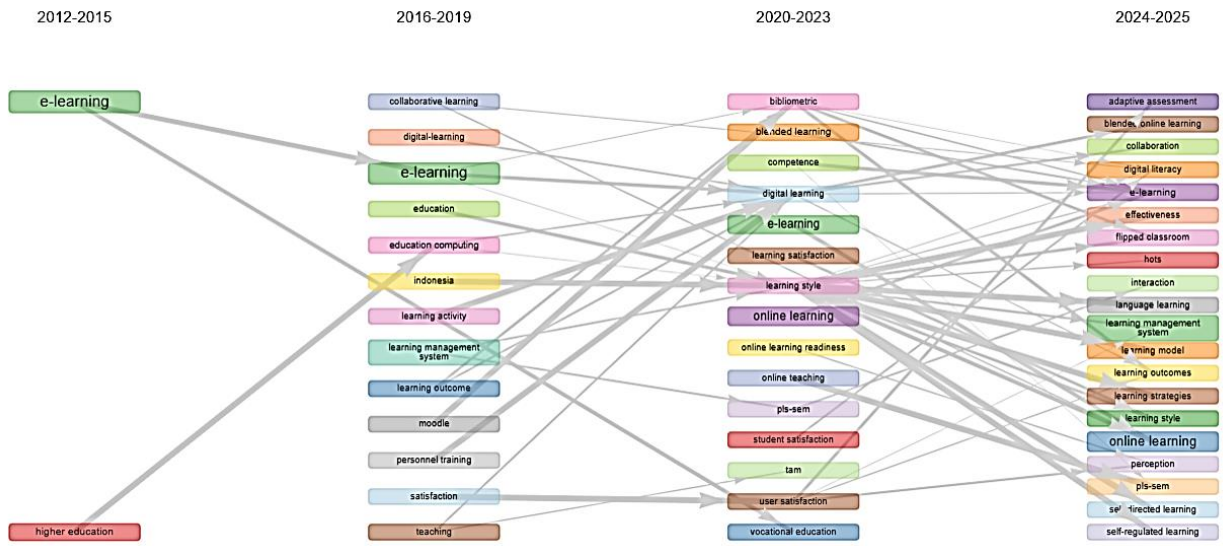


Figure 6. Evolving thematic landscape of digital education research in Indonesia between 2021 and early 2025. (*source: Biblioshiny analysis results*)[70]

In the 2016–2019 period, the thematic landscape expanded significantly. The field saw the rise of motor themes such as education computing, digital learning, and school psychology, reflecting both the diversification of educational contexts and increased sophistication in digital pedagogy. Collaborative learning continued to play an important role, transitioning to a basic theme underpinning emerging lines of inquiry. Other foundational themes—"education", "learning activity", and "culture"—also gained relevance and were frequently linked to previously established concepts. Meanwhile, emerging themes such as Indonesia, Moodle, and adaptive learning began to gain traction, signaling a localized interest in digital tools and their application in the national education system.

The 2020–2023 period was strongly shaped by the COVID-19 pandemic, which catalyzed a dramatic shift in research priorities. During this period, 'e-learning' and 'learning systems' returned as motor themes, underscoring their critical role in sustaining educational continuity during school closures. Simultaneously, the keyword COVID-19 entered the map as a basic theme, representing the immediate impact of the global health crisis on digital education discourse. Vocational education, blended learning, and higher education remained relevant foundational areas, while bibliometric research emerged as a niche theme, reflecting increased interest in measuring research productivity and trends. Notably, 21st-century skills appeared in the emerging/declining quadrant, suggesting a growing awareness and emphasis on the competencies required for learners to thrive in digital and post-pandemic learning environments.

The field continued to mature in 2024–2025, with a thematic shift toward learner-centered and evaluative frameworks. Motor themes during this time included "digital literacies", "open and distance education", "e-learning", and "self-efficacy". These themes

[70] Aria and Cuccurullo, "Bibliometrix : An R-Tool for Comprehensive Science Mapping Analysis."

emphasize empowering students, assessing readiness, and promoting autonomous learning in digital contexts. At the same time, several enduring concepts such as e-learning, blended learning, and digital learning remained basic themes, demonstrating their continued relevance as foundational components of digital education research. The map also revealed a heightened level of niche specialization, with smaller but internally cohesive clusters exploring specific subtopics. Meanwhile, themes such as "training", "language learning", and "learning management system" appeared in the emerging or declining quadrant, suggesting that while these topics remain present, their centrality in current research is diminishing.

The temporal evolution of research themes from 2012 to 2025 reflects a dynamic and responsive scholarly field. It has transitioned from foundational exploration of digital tools toward more complex investigations involving student agency, pedagogical innovation, digital competencies, and impact evaluation. This trajectory aligns closely with Indonesia's national education reforms and global trends in technology-enhanced learning.

Thematic Evolution by Period

A closer inspection of thematic evolution across sub-periods is crucial for the reader to understand how research on the digital transformation of education in Indonesia has developed conceptually and contextually over time. This analysis captures not only the emergence and persistence of key themes but also their shifting roles in the intellectual structure of the field. Four distinct periods—(2012 to 2015); (2016 to 2019); (2020 to 2023), and (2024 to 2025)—serve as milestones for mapping these thematic transitions.

In 2012–2015, the dominant motor themes were e-learning, collaborative learning, and computer-aided instruction. These themes represent the foundational core of the field and reflect the early focus on integrating basic digital technologies into pedagogical practices. As a basic theme, "higher education" indicates that early research was primarily situated in university settings, likely due to better access to technological infrastructure and academic resources. This period is characterized by exploratory research and theory-building around digital instructional modalities.

During the 2016–2019 period, thematic expansion and diversification became evident. "Education computing", "digital learning", and "school psychology" emerged as motor themes, illustrating a growing integration of digital technology into diverse educational domains. Collaborative learning transitioned into a basic theme, providing a conceptual anchor while supporting other lines of inquiry. Additionally, themes such as "education", "learning activity", and "culture" gained visibility, often intersecting with prior dominant themes. The emergence of "Indonesia", "Moodle, and adaptive learning" as emerging or declining themes suggests a localized effort to adapt global digital tools within Indonesian educational contexts and growing interest in personalized learning technologies.

In the 2020–2023 period, the impact of the COVID-19 pandemic became a defining influence on the thematic landscape. "E-learning" and "learning systems" emerged as central motor themes, reaffirming their critical role in sustaining learning continuity during periods of physical school closure. COVID-19 became a basic theme, reflecting the pandemic's immediate and widespread influence on education systems. Other foundational themes

during this period included "vocational education", "blended learning", and "higher education", which continued to serve as structural backdrops for digital innovation. The appearance of bibliometrics as a niche theme signified a growing interest in the meta-analysis and evaluation of scientific output in the field. Notably, "21st-century skills" appeared as an emerging theme, underscoring the shift toward future-oriented competencies necessary for navigating digital and hybrid learning environments.

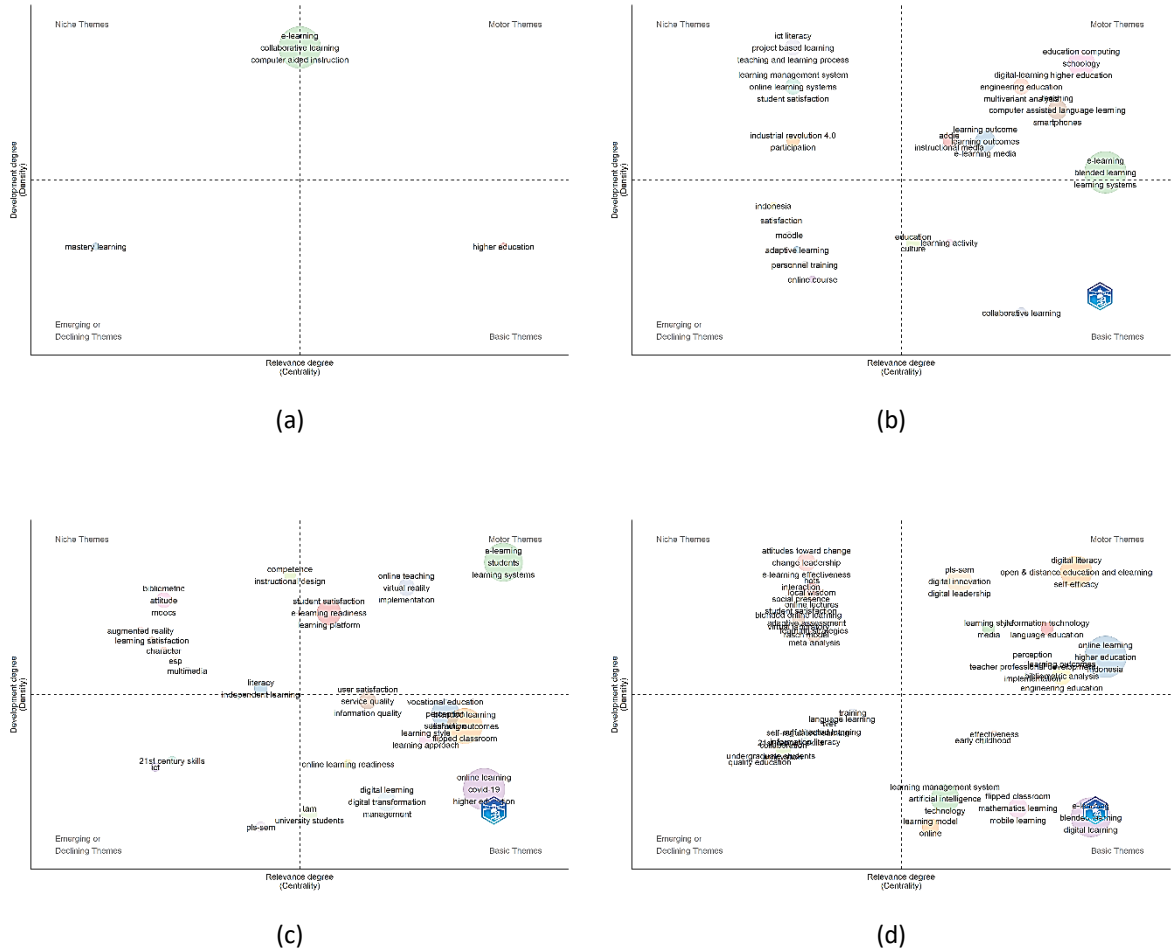


Figure 7. The diagrams show the thematic map for the period (a) 2012 to 2015, (b) 2016 to 2019, (c) 2020 to 2023, and (d) 2024 to May, 31, 2025. (*source: biblioshiny analysis results*)[71]

By 2024–2025, the field showed thematic maturity and specialization. Motor themes included "digital literacies", "open and distance education", "e-learning", and "self-efficacy", reflecting a heightened focus on learner agency, equity of access, and personal development in digital learning contexts. At the same time, persistent foundational themes such as "e-learning", "blended learning", and "digital learning" remained in the basic themes quadrant, underscoring their continued relevance despite the emergence of newer constructs. The presence of a larger number of niche themes during this period suggests that researchers are

[71] Aria and Cuccurullo.

engaging more deeply with specific subfields and educational challenges. Conversely, themes such as "training", "language learning", and "learning management system" appeared in the emerging or declining quadrant, implying either a saturation of research attention or a relative loss of centrality in the post-pandemic discourse.

The thematic evolution illustrates a transition from generalized technology integration to more nuanced, impact-driven, learner-focused research. The trajectory aligns with Indonesia's ongoing educational reforms and broader global movements toward personalized, equitable, and evidence-based digital learning systems.

Discussion

This bibliometric analysis provides a comprehensive overview of the research landscape surrounding the digital transformation of education in Indonesia between 2012 and 2025. Several critical insights emerge from the longitudinal data, reflecting the dynamic evolution of themes, author collaboration patterns, institutional contributions, and thematic orientations in response to national reforms, technological advancements, and global disruptions such as the COVID-19 pandemic.

Research Growth and Temporal Patterns

The consistent upward trend in publication output, particularly the exponential growth during the 2020–2022 period, underscores the significant role of the pandemic as a catalyst for educational change and scholarly inquiry. This surge reflects the urgent need for alternative learning solutions during school closures and the broader institutional shift toward online and blended learning models.[72] Notably, the sustained level of publication after the pandemic suggests that digital education is no longer viewed as a temporary solution but as a fundamental component of Indonesia’s educational future.[73]

This growth is also indicative of increased academic awareness and institutional support for research in digital learning.[74] The high compound annual growth rate (CAGR) of 37.87% highlights the acceleration of knowledge production in the field, aligning with global patterns observed in technology-enhanced learning domains. The high average citation rate per article and large volume of references demonstrate this research area's intellectual depth and intertextual connectivity.

Thematic Progression

The thematic evolution shows a clear trajectory from broad, technology-focused themes (e.g., e-learning, computer-aided instruction) to more learner-centered and impact-oriented topics such as self-efficacy, digital literacy, and adaptive assessment. The early dominance of e-learning and collaborative learning provided the necessary theoretical

[72] Qurrotu Aini, Andy Kurniawan, and Tutur Bina Sulistiyowati, “Digital Transformation: Best Practices of Educational Platform in Indonesia,” *Jurnal Transformative* 10, no. 1 (March 31, 2024): 42–59, https://doi.org/10.21776/ub.transformative.2024.010.01.3.

[73] Johni Eka Putra, A Sobandi, and Aisah Aisah, “The Urgency of Digital Technology in Education: A Systematic Literature Review,” *Jurnal EDUCATIO: Jurnal Pendidikan Indonesia* 10, no. 1 (May 22, 2024): 224, https://doi.org/10.29210/1202423960.

[74] Mufarrihul Hazin et al., “Analyzing Digitalization in Education Policy in Indonesia through the Policy Analysis Triangle Model,” *Journal of Posthumanism* 5, no. 1 (April 7, 2025), https://doi.org/10.63332/joph.v5i1.631.

foundation upon which later developments—such as gamification, AI integration, and competency-based learning—have been built.

The increasing prominence of themes such as "digital literacies" and "open and distance education" in recent years suggests a shift toward inclusivity, accessibility, and digital readiness, in alignment with Indonesia's national education goals, including the *Merdeka Belajar* initiative. Furthermore, the sustained relevance of blended learning indicates that hybrid delivery models remain central to ongoing pedagogical innovation, particularly in higher education.

Research Collaboration and Institutional Leadership

The results also demonstrate a robust culture of academic collaboration, with an average of nearly four authors per article and strong institutional clusters among top public universities. Institutions such as Universitas Negeri Malang, Universitas Pendidikan Indonesia, and Universitas Negeri Yogyakarta play leading roles in shaping the field, supported by increasing contributions from private institutions like Bina Nusantara University.

Although international collaboration accounts for only 16.71% of total publications, its presence reflects growing scholarly networks and the potential for future expansion. Cross-border partnerships are significant for advancing research in digital education, as they provide access to comparative frameworks, diverse methodologies, and transnational funding sources.

Implications for Policy and Practice

The insights from this study offer several implications for policy, practice, and future research. First, the strong alignment between national education policies and research themes suggests that scholarly output is responsive to regulatory and institutional shifts.[75] This dynamic creates opportunities for more policy-research integration, particularly in areas such as curriculum reform, teacher training, and the development of digital infrastructure.[76] Second, the emergence of themes like student engagement, self-directed learning, and evaluation frameworks implies a growing recognition of student-centered approaches.[77] These directions resonate with global educational movements toward personalized learning and call for empirical investigations into the long-term effectiveness of these innovations.

The presence of declining themes such as "training" and "learning management systems" suggests a potential shift from platform-centric discussions to more pedagogically driven and learner-focused studies. This maturation is a promising sign for developing Indonesia's more critically reflective and evidence-based research culture.

Limitations and Future Directions

While this study offers a comprehensive bibliometric overview of digital education research in Indonesia, several limitations should be acknowledged.[78] The analysis was

[75] Adhi Prasetio, Grisna Anggadwita, and Rina D. Pasaribu, "Digital Learning Challenge in Indonesia," 2021, 56–71, https://doi.org/10.4018/978-1-7998-4972-8.ch004.
[76] Rasimin et al., "Multi-Dimensional Challenges in the Indonesian Social Science Information Technology-Based Learning: A Systematic Literature Review," *Heliyon* 10, no. 7 (April 2024): e28706, https://doi.org/10.1016/j.heliyon.2024.e28706.
[77] Putra, Sobandi, and Aisah, "The Urgency of Digital Technology in Education: A Systematic Literature Review."
[78] Moral-Muñoz et al., "Software Tools for Conducting Bibliometric Analysis in Science: An up-to-Date Review."

confined to Scopus-indexed journal articles, excluding potentially relevant literature from national journals, conference proceedings, and grey literature.[79] Additionally, reliance on author keywords and Keywords Plus introduces terminological variation that may affect thematic clustering. Including early 2025 publications, some of which have yet to accumulate citations, may also skew citation-based impact analyses.[80] Furthermore, while co-authorship patterns were mapped, the study did not capture qualitative dimensions of collaboration, such as equity or depth of engagement.

Future research should address these gaps by conducting comparative studies with other developing countries, incorporating altmetrics and public engagement indicators, and exploring emerging intersections with AI, ethics, and post-pandemic innovations. Longitudinal studies on institutional and learner-level impacts could enhance the field's relevance. Addressing these areas will support a deeper theoretical and practical understanding of digital transformation in education within Indonesia and comparable global contexts.

CONCLUSION

This study makes a unique and significant contribution to the field by providing a comprehensive bibliometric mapping of the digital transformation of education in Indonesia from 2012 to early 2025, based on Scopus-indexed publications. By examining trends in publication output, thematic evolution, keyword co-occurrence, author and institutional productivity, and collaboration networks, the study effectively answers the research questions and fulfills its stated objectives. The results reveal a significant surge in research activity beginning in 2020, influenced by the COVID-19 pandemic and government-led educational reforms such as *Merdeka Belajar*. Dominant themes include e-learning, online learning, and blended learning, while newer areas such as digital literacy, gamification, and student engagement have gained prominence in recent years. The findings also show that research contributions are concentrated in a few highly productive public universities, with collaboration networks steadily expanding but still limited in depth and international reach.

The implications of this study are both scholarly and practical. From an academic perspective, it provides a structured overview of research developments and thematic gaps, serving as a strategic resource for future studies. However, the study's practical implications for policymakers and practitioners are particularly noteworthy. The insights can inform targeted investments in teacher training, curriculum development, and digital infrastructure to support the continued transformation of education in Indonesia. It is important to note that this study is limited by its reliance on Scopus-indexed sources, excluding potentially relevant national or regional literature and grey literature such as dissertations or policy reports. Additionally, keyword-based thematic clustering is inherently sensitive to terminological variation.

[79] Chansanam and Li, "KKU-BiblioMerge: A Novel Tool for Multi-Database Integration in Bibliometric Analysis."
[80] HimaJyothi Kasaraneni and Salini Rosaline, "Automatic Merging of Scopus and Web of Science Data for Simplified and Effective Bibliometric Analysis," *Annals of Data Science* 11, no. 3 (June 7, 2024): 785–802, https://doi.org/10.1007/s40745-022-00438-0.

Future research should expand the scope to include comparative analyses across Southeast Asian countries, integrate alternative metrics to assess real-world impact, and explore thematic intersections with emerging technologies such as AI in education. It's crucial to note that these future research directions are not just suggestions, but necessary steps to address the limitations of the current study. Longitudinal studies tracking institutional or student-level outcomes could also enhance the practical relevance of bibliometric research. Ultimately, this study lays a foundation for sustained inquiry into how digital transformation reshapes education in Indonesia, offering evidence-based direction for scholarly and policy-oriented action.

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