



DIGITAL TRANSFORMATION IN INDONESIAN EDUCATION: TRENDS, COLLABORATION, AND FUTURE RESEARCH DIRECTIONS

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ABSTRACT

This study analyzes the development of digital transformation research in Indonesian education by identifying publication trends, dominant themes, collaboration patterns, and future research directions. A bibliometric approach was applied to 479 Scopus-indexed publications published between 1978 and 2026. Data were analyzed using VOSviewer and Biblioshiny to examine publication growth, productive authors and institutions, citation patterns, thematic evolution, and keyword co-occurrence networks. Research on digital transformation in Indonesian education has grown significantly, particularly after the COVID-19 pandemic, with an annual publication growth rate of 9.93%. Dominant themes include e-learning, educational technology, online learning, digital learning systems, and higher education transformation. Emerging topics such as artificial intelligence, adaptive learning, gamification, and digital literacy reflect increasing diversification of research interests. Indonesian universities play a strategic role in advancing digital transformation research through collaborative and interdisciplinary scholarly networks. The novelty of this study lies in integrating bibliometric mapping and thematic analysis to examine the intellectual structure, thematic evolution, and future research opportunities of digital transformation in Indonesian education. The findings provide insights for developing inclusive, adaptive, and sustainable digital education ecosystems.

ABSTRAK

Penelitian ini menganalisis perkembangan kajian transformasi digital dalam pendidikan di Indonesia melalui identifikasi tren publikasi, tema dominan, pola kolaborasi, dan arah penelitian masa depan. Pendekatan bibliometrik diterapkan pada 479 publikasi yang terindeks Scopus selama periode 1978–2026. Data dianalisis menggunakan perangkat lunak VOSviewer dan Biblioshiny untuk mengidentifikasi pertumbuhan publikasi, penulis dan institusi produktif, pola sitasi, evolusi tema, serta jaringan ko-occurrence kata kunci. Kajian transformasi digital dalam pendidikan di Indonesia menunjukkan pertumbuhan yang signifikan, terutama setelah pandemi COVID-19, dengan tingkat pertumbuhan publikasi tahunan sebesar 9,93%. Tema dominan meliputi e-learning, teknologi pendidikan, pembelajaran daring, sistem pembelajaran digital, dan transformasi pendidikan tinggi. Tema-tema baru seperti kecerdasan buatan, adaptive learning, gamifikasi, dan literasi digital mencerminkan semakin beragamnya fokus penelitian. Perguruan tinggi di Indonesia memiliki peran strategis dalam pengembangan riset transformasi digital melalui jaringan kolaborasi ilmiah yang bersifat interdisipliner. Kebaruan penelitian terletak pada integrasi pemetaan bibliometrik dan analisis tematik untuk mengkaji struktur intelektual, evolusi tema, serta peluang penelitian masa depan terkait transformasi digital dalam pendidikan di Indonesia. Temuan penelitian memberikan kontribusi bagi pengembangan ekosistem pendidikan digital yang inklusif, adaptif, dan berkelanjutan.

Kata Kunci: Transformasi Digital; Pendidikan Indonesia; Teknologi Pendidikan; Analisis Bibliometrik; Pembelajaran Digital

INTRODUCTION

In contemporary education systems worldwide. The integration of digital technologies into educational processes has transformed teaching practices, learning environments, institutional governance, and educational access across multiple levels of education (Kumar, 2025). In Indonesia, the acceleration of digital transformation became particularly evident during the COVID-19 pandemic, which forced educational institutions to rapidly adopt online and hybrid learning models to sustain educational continuity (Pramana et al., 2020). Since then, digital transformation has evolved beyond emergency remote learning and has become a strategic agenda for improving educational quality, accessibility, and sustainability within the Indonesian education system (Suwono et al., 2026).

Globally, digital transformation has become a strategic priority in education systems seeking to improve learning quality, institutional resilience, and educational accessibility in the post-pandemic era (Kumar, 2025). In developing countries such as Indonesia, however, digital transformation is often shaped by complex interactions among technological readiness, policy implementation, educational inequality, and socio-cultural conditions (Prihatin et al., 2025). The Indonesian government has introduced various policies and digital initiatives to support educational transformation, including Merdeka Mengajar, Belajar.id, Rapor Pendidikan, and the Digital Maturity Index (IKD-PT), which aim to strengthen digital ecosystems, improve teacher competencies, and enhance institutional readiness for digital learning environments (Fahmi et al., 2025; Saa, 2024). These initiatives reflect a broader commitment toward achieving equitable and sustainable education through digital innovation (Sholeh et al., 2025). In higher education and school contexts, digital transformation has encouraged the adoption of learning management systems (LMS), blended learning, flipped classrooms, Zoom-based learning environments, and other technology-supported pedagogical models that facilitate more flexible and student-centered learning experiences (Amin et al., 2023; Baskara et al., 2024).

Despite significant progress, the implementation of digital transformation in Indonesian education remains uneven and complex. Several studies indicate that disparities in digital infrastructure, internet access, and technological readiness between urban and rural regions continue to hinder equitable educational transformation (Jaya et al., 2024; Yaqin et al., 2023). Rural schools frequently face limitations related to connectivity, digital devices, funding, and teacher digital literacy, resulting in unequal access to digital learning opportunities (Ihsaniyati et al., 2024; Onitsuka et al., 2018). Furthermore, challenges associated with traditional pedagogical practices, insufficient ICT competencies, fragmented policy implementation, and cultural resistance also affect the effectiveness of digital integration in educational settings (Prasojo et al., 2019).

Teacher competence has emerged as a central factor influencing the success of digital transformation in education. Previous studies emphasize the importance of Technological Pedagogical Content Knowledge (TPACK) in helping educators integrate technology effectively into instructional practices (Chang et al., 2025; Sulistyowati & Adira, 2025). Professional development programs, co-design workshops, and differentiated digital training models have been identified as essential strategies for improving teachers' digital readiness and pedagogical innovation (Ansyari, 2015; So et al., 2019). However, the effectiveness of these initiatives often varies depending on institutional support, digital culture, infrastructure availability, and contextual educational conditions. The digital transformation of education can also be understood through a socio-technical perspective, which emphasizes the interaction between technological infrastructure, institutional governance, human resources, and educational culture in shaping transformation outcomes (Anggono et al.,

2025). From this perspective, successful digital transformation requires not only technological adoption but also organizational readiness, digital leadership, and sustainable educational innovation.

In recent years, digital transformation research in Indonesia has expanded across various educational domains, including digital literacy, online learning, educational leadership, e-learning adoption, digital governance, artificial intelligence integration, and educational equity (Imbar et al., 2022). This growing body of research demonstrates the increasing scholarly attention toward digital transformation and its implications for educational development in Indonesia (Yaqin et al., 2023). Nevertheless, existing studies are often fragmented, focusing on specific technologies, isolated educational contexts, or short-term implementation issues. Comprehensive mapping studies that systematically examine research trends, collaboration networks, dominant themes, and future research directions in digital transformation within Indonesian education remain limited.

Despite the growing number of publications on digital transformation in Indonesian education, the existing body of literature remains fragmented across various educational levels, technological platforms, pedagogical approaches, and policy contexts. Previous studies have primarily focused on specific aspects of digital transformation, such as online learning implementation during the COVID-19 pandemic (Pramana et al., 2020), learning management system adoption in higher education (Rahman & Arifin, 2019), teacher digital competencies and TPACK development (Chang et al., 2025), digital divide issues (Yaqin et al., 2023), and educational technology integration in schools and universities ((Habibi et al., 2023). Several recent studies have also discussed digital transformation policies and educational governance in Indonesia (Anggono et al., 2025; Prihatin et al., 2025), as well as the implementation of digital learning ecosystems and educational innovation (Asia et al., 2026; Baskara et al., 2024). However, these studies tend to examine digital transformation from isolated perspectives and specific educational contexts, without providing a comprehensive overview of the overall development of research in the field. Consequently, a systematic understanding of publication trends, intellectual structures, collaboration networks, dominant research themes, and emerging directions within digital transformation research in Indonesian education remains limited. In this context, bibliometric analysis becomes important as a methodological approach for systematically mapping the scientific landscape and identifying patterns of knowledge development within the field (Cassandra et al., 2025).

Although previous studies have explored digital education and technology integration in Indonesia, bibliometric investigations specifically examining the evolution of digital transformation research in Indonesian education are still relatively scarce. Existing bibliometric-related studies mainly focus on limited domains, such as digital education trends (Cassandra et al., 2025), online learning practices, or educational technology adoption, without comprehensively integrating publication trends, thematic evolution, collaborative networks, and future research directions within a single analytical framework. Therefore, this study offers a novel contribution by integrating bibliometric mapping and thematic analysis to examine publication trends, collaboration patterns, thematic development, and future research directions related to digital transformation in Indonesian education. This study not only visualizes the intellectual landscape of the field but also provides a broader understanding of research development and potential gaps that may guide future educational research, policy formulation, and digital innovation practices in Indonesia.

Bibliometric analysis provides a systematic approach for identifying intellectual structures, publication trends, thematic evolution, collaborative patterns, and emerging

research directions within a particular field of study. Through bibliometric mapping, researchers can better understand the development of scientific knowledge, influential publications, dominant research themes, and potential gaps requiring further investigation. Previous bibliometric studies in education have demonstrated the effectiveness of this approach in visualizing scientific landscapes and identifying future research opportunities (Cassandra et al., 2025). However, bibliometric investigations specifically focusing on digital transformation in Indonesian education are still relatively scarce.

Therefore, this study aims to analyze the development of digital transformation research in Indonesian education through a bibliometric approach. Specifically, this study seeks to identify publication trends, leading authors, institutional collaborations, dominant research themes, and emerging topics related to digital transformation in Indonesian educational contexts. In addition, this study aims to provide future research directions that may contribute to the development of more inclusive, adaptive, and sustainable digital education systems in Indonesia. By mapping the intellectual landscape of this field, the study is expected to contribute theoretically to the growing discourse on digital transformation in education and practically to policymakers, educational institutions, and researchers seeking to strengthen digital innovation and educational equity in Indonesia. The significance of this study lies in its ability to provide a comprehensive foundation for understanding the evolution of digital transformation research within the Indonesian educational context. The findings offer valuable insights into the structure and dynamics of the field, enabling stakeholders to recognize emerging opportunities, strengthen interdisciplinary collaboration, and address underexplored areas of research. Moreover, the study provides an evidence-based reference for supporting strategic planning, policy development, and institutional decision-making related to digital transformation, thereby contributing to the advancement of a more effective, equitable, and sustainable education system in Indonesia.

RESEARCH METHOD

This study employed a bibliometric approach to analyze the development of research on digital transformation in Indonesian education. Bibliometric analysis was selected because it enables the systematic mapping of scientific publications, intellectual structures, collaboration patterns, thematic evolution, and emerging research trends within a particular field of study (Donthu et al., 2021). Through this approach, the study aimed to identify publication growth, influential authors, productive institutions, dominant themes, and future research directions related to digital transformation in Indonesian education.

The data used in this study were obtained from the Scopus database, which is widely recognized as one of the largest and most comprehensive international scientific databases for bibliometric research. Scopus was selected because of its extensive journal coverage, citation indexing features, and compatibility with bibliometric software such as VOSviewer and Biblioshiny (Sharma et al., 2025). Data collection was conducted in March 2026 using the following Boolean search string: TITLE-ABS-KEY (("digital transformation" OR "educational technology" OR "digital learning" OR "online learning" OR "digital education") AND (education) AND (Indonesia OR Indonesian))

The search process focused on journal articles and conference papers published in English and indexed in Scopus. To ensure the relevance and quality of the dataset, several inclusion and exclusion criteria were applied. The inclusion criteria consisted of: (1) publications discussing digital transformation or digital technology implementation in educational contexts; (2) studies focusing on Indonesian educational settings; (3) journal articles and conference proceedings indexed in Scopus; and (4) publications written in

English. Meanwhile, publications unrelated to education, duplicate records, inaccessible documents, publications still in press, editorials, notes, and documents lacking sufficient bibliographic information were excluded from the analysis.

The study selection process followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework to ensure transparency and systematic data screening. Based on the keyword identification process conducted through article titles, abstracts, and keywords, the initial search identified 586 records from the Scopus database. No duplicate records were identified during the screening process. Subsequently, 90 records were excluded because they did not meet the document type and regional focus criteria, particularly publications other than journal articles and conference proceedings or studies not specifically related to Indonesia. As a result, 496 records remained for further screening. After the eligibility assessment process, an additional 17 records were excluded because they were still categorized as “in press” publications or were not published in English. Consequently, a total of 479 publications met all eligibility criteria and were included in the final bibliometric analysis. The detailed study selection process is presented in Figure 1.

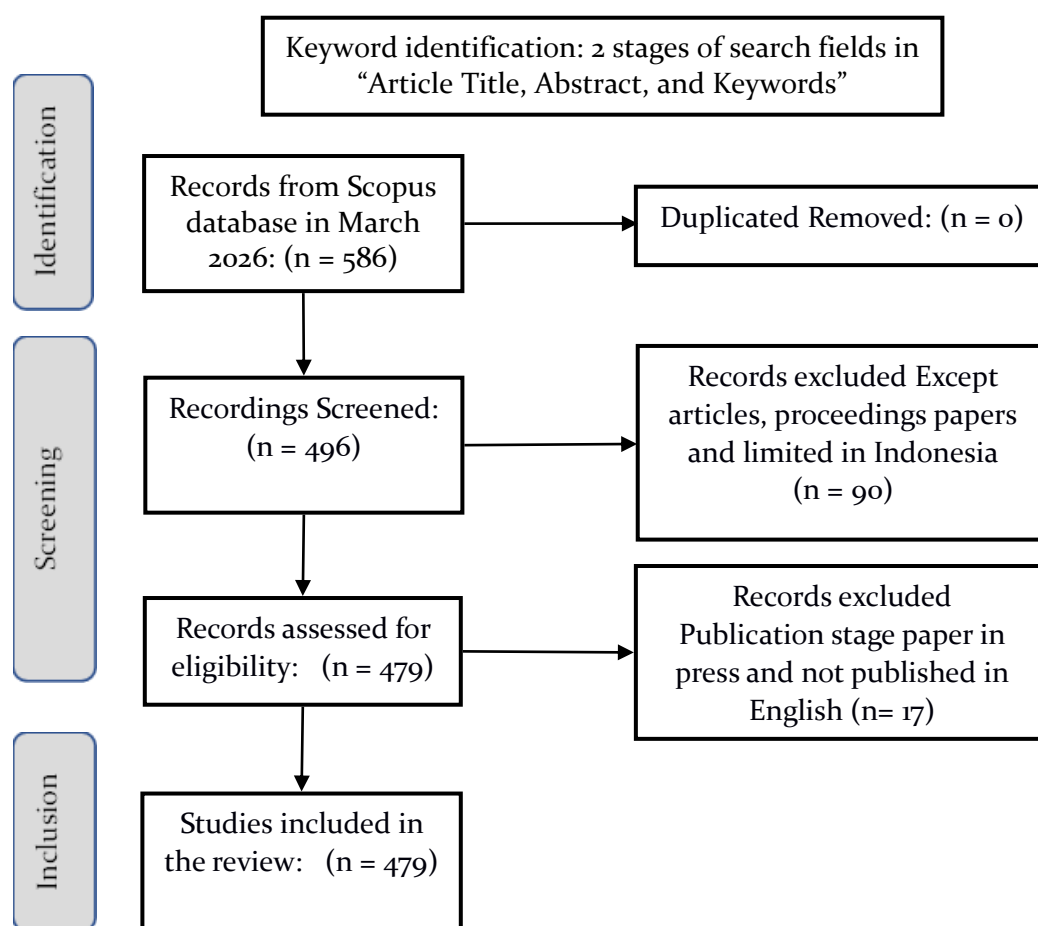


Figure 1. The PRISMA Flow Chart adapted from Rullyana, Siregar, and Kustandi (2025)}

Figure 1 illustrates the PRISMA flow chart adapted from Johan et al. (2025), which consists of three main stages: identification, screening, and inclusion. The identification stage involved searching publications using the predefined Boolean keywords in Scopus. The screening stage focused on filtering publication types, regional relevance, and language

criteria, while the inclusion stage determined the final dataset used in the bibliometric analysis.

The bibliographic data were exported from Scopus in CSV formats and analyzed using VOSviewer and Biblioshiny software. VOSviewer was utilized to visualize co-authorship networks, keyword co-occurrence, citation relationships, and thematic clusters (Chatterjee & Mohanty, 2023). Meanwhile, Biblioshiny, a web-based interface of the Bibliometrix package in R, was employed to analyze publication trends, annual scientific production, source dynamics, thematic evolution, and collaboration patterns (Aria & Cuccurullo, 2017). The analysis focused on several bibliometric indicators, including annual publication growth, leading authors, productive institutions, country collaboration, citation analysis, keyword occurrence, and thematic mapping.

To strengthen the interpretation of bibliometric findings, this study also applied thematic analysis to identify dominant research themes and emerging research directions within the field of digital transformation in Indonesian education. The thematic interpretation was conducted based on keyword clusters, co-occurrence analysis, and topic relationships generated through bibliometric visualization. This combination of bibliometric mapping and thematic analysis enabled a more comprehensive understanding of the intellectual landscape, research development patterns, and future opportunities for digital transformation studies in Indonesian education.

RESULT AND DISCUSSION

Result

Main Information

The bibliometric analysis identified 479 publications related to digital transformation in Indonesian education indexed in the Scopus database during 1978–2026, with an annual growth rate of 9.93%, indicating increasing scholarly attention to this field. The dataset involved 304 publication sources and 1,879 authors, reflecting the interdisciplinary and collaborative nature of digital transformation research. The average number of co-authors per document reached 4.27, while international co-authorship accounted for 21.92%, demonstrating growing national and international research collaboration. In addition, the dataset contained 1,562 author keywords and 20,601 references, indicating broad thematic diversity and a strong scientific foundation. The average document age of 2.39 years suggests that this field is relatively recent and rapidly developing, particularly after the COVID-19 pandemic, while the average citation per document of 3.344 reflects increasing academic recognition of digital transformation research in Indonesian education.

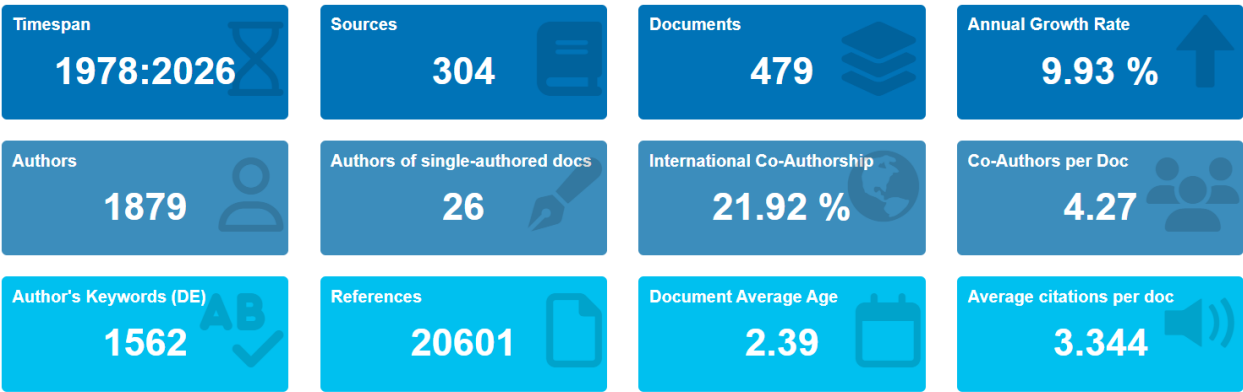


Figure 2. Main Information
Source: Biblioshiny (2026)

Document by Years

The annual scientific production graph demonstrates that research on digital transformation in Indonesian education remained relatively limited from 1978 to the late 2010s, with only a small number of publications produced each year. However, publication growth began to increase significantly after 2020, coinciding with the rapid expansion of digital learning and technology adoption during the COVID-19 pandemic. The sharp rise in publications reached its peak in 2025, indicating heightened scholarly attention toward digital transformation, online learning, educational technology, and digital innovation within Indonesian educational contexts. Although the number of publications slightly declined in 2026, this decrease is likely influenced by the ongoing indexing process and incomplete publication records for the current year. Overall, the trend illustrates that digital transformation has emerged as a rapidly growing and increasingly important research area in Indonesian education.

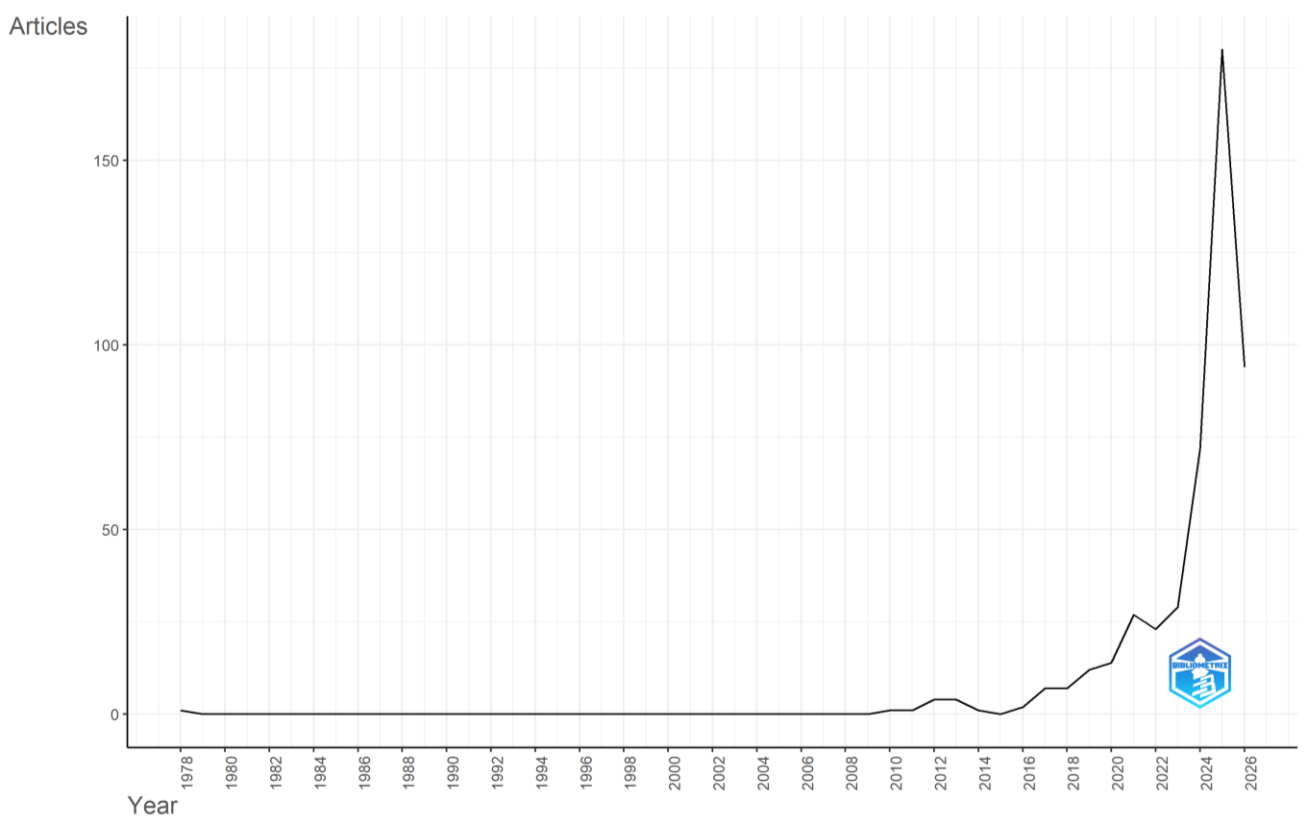


Figure 2. Annual Scientific Production on Digital Transformation Research in Indonesian Education (1978–2026)

Source: Processed bibliometric data from Scopus database using Biblioshiny (2026)

Most Relevant Sources

The analysis of the most relevant sources indicates that research on digital transformation in Indonesian education is distributed across interdisciplinary journals and conference proceedings related to education, technology, and applied sciences. The *International Journal of Learning, Teaching and Educational Research* emerged as the most productive source with 13 publications, followed by *AIP Conference Proceedings* with 12 publications and the *International Journal of Information and Education Technology* with 11 publications. Several other influential sources included *Cogent Education*, *Journal of Physics:*

Conference Series, and *Multidisciplinary Science Journal*, each contributing a substantial number of publications to the field. The presence of conference proceedings such as *ACM International Conference Proceeding Series* and *ICET 2025 Proceedings* also demonstrates the strong role of academic conferences in disseminating research on digital transformation and educational technology in Indonesia. Overall, these findings suggest that digital transformation research in Indonesian education has developed within diverse scientific platforms, reflecting the interdisciplinary and rapidly evolving nature of the field.

Table 1. Most Relevant Sources in Digital Transformation Research in Indonesian Education

No	Sources	Articles
1	International Journal Of Learning, Teaching And Educational Research	13
2	Aip Conference Proceedings	12
3	International Journal Of Information And Education Technology	11
4	Cogent Education	10
5	Journal Of Physics: Conference Series	10
6	Multidisciplinary Science Journal	10
7	Acm International Conference Proceeding Series	8
8	Multidisciplinary Reviews	7
9	Journal Of Engineering Science And Technology	5
10	Proceedings - 2025 11th International Conference On Education And Technology: Personalized Ai For Digital Well-Being: Bridging Technology And Humanity, Icet 2025	5

Source: Processed bibliometric data from Scopus database using Biblioshiny (2026).

The Bradford's Law analysis demonstrates the distribution pattern of publication sources related to digital transformation research in Indonesian education. The results indicate that the publications are concentrated within a relatively small number of highly productive core sources, followed by a larger number of less productive journals and conference proceedings. The core zone consists of 31 sources that contributed the highest concentration of publications in the field, indicating that a limited number of journals and proceedings play a dominant role in disseminating research on digital transformation in Indonesian education. Meanwhile, Zone 2 contains 114 sources, and Zone 3 includes 159 sources with lower publication frequencies. This distribution pattern is consistent with Bradford's Law, which suggests that scientific knowledge production is typically concentrated in a small set of influential sources while the remaining publications are dispersed across a broader range of outlets. The findings also reflect the interdisciplinary nature of digital transformation research, which spans education, technology, engineering, and social sciences, resulting in publication dispersion across various academic platforms.

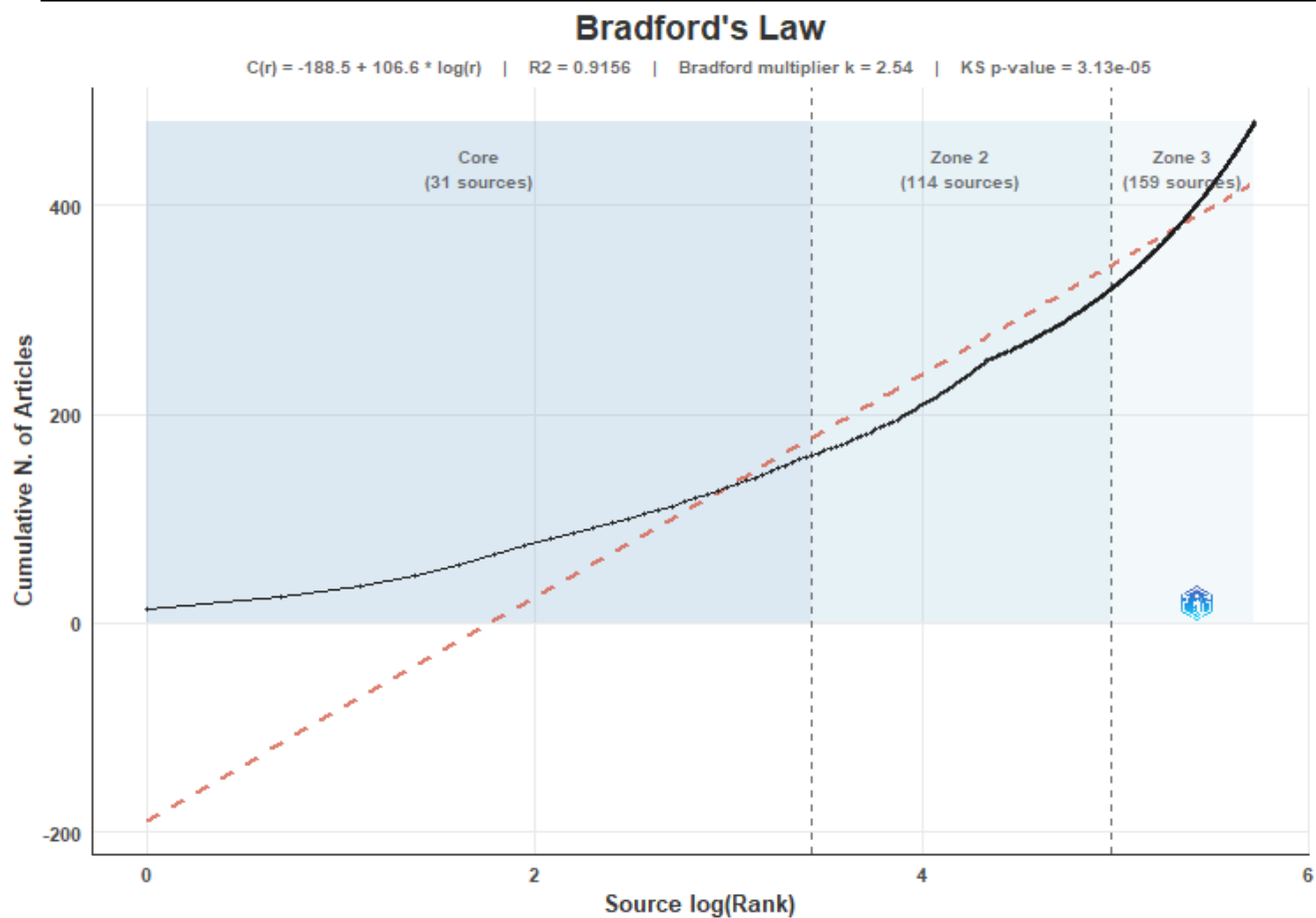


Figure 3. Bradford’s Law Distribution of Sources in Digital Transformation Research in Indonesian Education
Source: Processed bibliometric data from Scopus database using Biblioshiny (2026).

The Most Productive Authors

The analysis of the most productive authors reveals several researchers who have made significant contributions to the development of digital transformation research in Indonesian education. Aditya BR and Langi AZR emerged as the most productive authors, each contributing five publications, followed by Bandung Y, Ferdiana R, Kusumawardani SS, Muktiarni M, and Prasetyaningtyas SW with four publications each. Meanwhile, Aini Q, Asmar A, and Dewi DA contributed three publications respectively. In addition to publication counts, the fractionalized article indicator demonstrates the relative contribution of each author within collaborative publications. Aditya BR recorded the highest fractionalized contribution (1.7), followed by Langi AZR (1.58) and Bandung Y (1.37), indicating substantial involvement in co-authored research. These findings suggest that digital transformation research in Indonesian education is characterized by collaborative scholarly networks involving researchers from various institutions and disciplinary backgrounds. The dominance of collaborative publications also reflects the interdisciplinary nature of digital transformation studies, which integrate perspectives from education, technology, digital governance, and instructional innovation.

Table 2. The Most Productive Authors in Digital Transformation Research in Indonesian Education

No	Authors	Articles	Articles Fractionalized
1	Aditya BR	5	1,7
2	Langi AZR	5	1,58333333
3	Bandung Y	4	1,36666667
4	Ferdiana R	4	1,2
5	Kusumawardani SS	4	1,2
6	Muktiarni M	4	0,62424242
7	Prasetyaningtyas SW	4	0,98333333
8	Aini Q	3	0,65
9	Asmar A	3	0,91666667
10	Dewi DA	3	0,45396825

Source: Processed bibliometric data from Scopus database using Biblioshiny (2026).

Authors with Most Citation

The citation analysis identified several influential authors who have received the highest local citations within the dataset of digital transformation research in Indonesian education. Aditya BR, Ferdiana R, and Kusumawardani SS emerged as the most cited authors, each receiving five local citations, indicating their significant influence on the development of research in this field. Al Husaeni DN followed with four local citations, while several other authors, including Al Husaeni DF, Al Obaidi ASM, Chalim S, Chano J, Fahmi M, and Haryanti ND, each received three local citations. These findings suggest that although the field of digital transformation in Indonesian education is relatively recent and rapidly evolving, several authors have already established notable academic influence through frequently cited publications. The citation patterns also indicate the emergence of key scholars whose works contribute substantially to discussions on educational technology, digital learning, and innovation within Indonesian educational contexts.

Table 3. Authors with the Highest Local Citations in Digital Transformation Research in Indonesian Education

No	Author	Local Citation
1	Aditya BR	5
2	Ferdiana R	5
3	Kusumawardani SS	5
4	Al Husaeni DN	4
5	Al Husaeni DF	3
6	Al Obaidi ASM	3
7	Chalim S	3
8	Chano J	3
9	Fahmi M	3
10	Haryanti ND	3

Source: Processed bibliometric data from Scopus database using Biblioshiny (2026).

Most Productive Universities

The analysis of institutional productivity shows that Indonesian universities play a significant role in the development of digital transformation research in education.

Universitas Pendidikan Indonesia emerged as the most productive institution with 33 publications, followed by Universitas Sebelas Maret with 28 publications and Universitas Negeri Padang with 27 publications. Other major contributors included Universitas Negeri Jakarta and Universitas Negeri Yogyakarta, each producing 19 publications, as well as Telkom University with 17 publications. Several other institutions, including Universitas Negeri Surabaya, Bina Nusantara University, Universitas Negeri Malang, and Universitas Padjadjaran, also demonstrated substantial research productivity in this field. The dominance of teacher education universities and technology-oriented institutions indicates that digital transformation research in Indonesian education is strongly connected to educational innovation, teacher development, digital learning systems, and educational technology integration. These findings also suggest that higher education institutions in Indonesia are increasingly active in responding to digital transformation challenges through collaborative and interdisciplinary research initiatives.

Table 4. Most Productive Universities in Digital Transformation Research in Indonesian Education

No	University	Number of Articles
1	Universitas Pendidikan Indonesia	33
2	Universitas Sebelas Maret	28
3	Universitas Negeri Padang	27
4	Universitas Negeri Jakarta	19
5	Universitas Negeri Yogyakarta	19
6	Telkom University	17
7	Universitas Negeri Surabaya	16
8	Bina Nusantara University	15
9	Universitas Negeri Malang	14
10	Universitas Padjadjaran	11

Source: Processed bibliometric data from Scopus database using Biblioshiny (2026)

Research Mapping and Network Analysis

Trend Topics on Digital Transofrmation on Indonesian Education Reseach

The trend topics analysis demonstrates the evolution of research themes related to digital transformation in Indonesian education over time. Early studies, particularly between 2012 and 2016, were primarily dominated by themes such as information technology, rural areas, teaching and learning, and information and communication technologies, reflecting the initial focus on technological infrastructure and ICT integration in educational settings. Between 2017 and 2020, research attention expanded toward learning technology, mobile learning, distance education, and mathematics learning, indicating increasing interest in digital learning innovation and technology-supported instructional practices. Following the COVID-19 pandemic, the research landscape shifted significantly toward topics such as digital learning, e-learning, higher education institutions, curriculum, students, and educational technology, demonstrating the rapid acceleration of digital transformation in educational systems. More recent themes emerging between 2023 and 2026 include adaptive learning, digital transformation, digital learning media, local wisdom, and engineering education, suggesting a transition from technology adoption toward more adaptive, contextual, and sustainability-oriented approaches in digital education research. Overall, the findings indicate that digital transformation research in Indonesian education has evolved from basic ICT integration toward more complex discussions involving pedagogical innovation, digital ecosystems, curriculum transformation, and contextualized educational technologies.

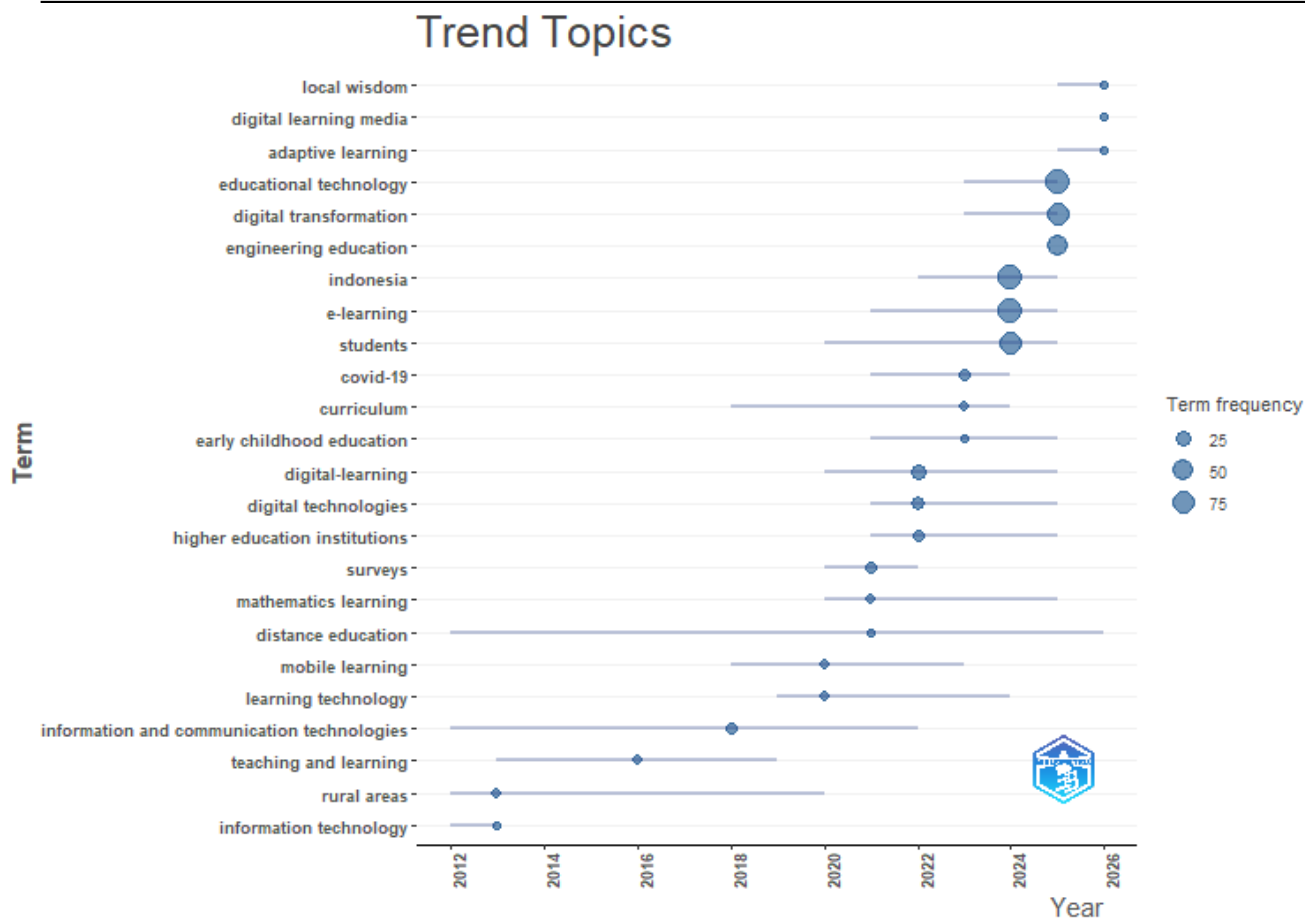


Figure 4. Trend Topics in Digital Transformation Research in Indonesian Education
Source: Processed bibliometric data from Scopus database using Biblioshiny (2026).

Thematic Distribution of Digital Transformation Research in Indonesian Education

The thematic distribution analysis reveals that research on digital transformation in Indonesian education is dominated by themes related to e-learning and Indonesia, each accounting for 8% of the total keyword occurrences with 92 frequencies respectively. Other prominent themes include educational technology (85 occurrences; 8%), students (68 occurrences; 6%), digital transformation (63 occurrences; 6%), engineering education (58 occurrences; 5%), higher education (48 occurrences; 4%), learning systems (46 occurrences; 4%), teaching (40 occurrences; 4%), and education computing (39 occurrences; 4%). The prominence of these themes indicates that digital transformation research in Indonesia has primarily focused on technology-supported learning environments, educational innovation, student engagement, and higher education transformation. Emerging themes such as artificial intelligence, digital literacy, digital technologies, gamification, blended learning, adaptive learning, and virtual learning environments further demonstrate the increasing diversification and sophistication of digital transformation studies in Indonesian education. In addition, the presence of themes such as curriculum, teachers, personal training, and learning management systems suggests growing attention toward pedagogical adaptation, teacher readiness, and institutional digital capacity. Overall, the findings indicate that digital transformation research in Indonesian education has evolved into a broad and interdisciplinary field encompassing educational technology, digital pedagogy, curriculum innovation, and emerging learning ecosystems.

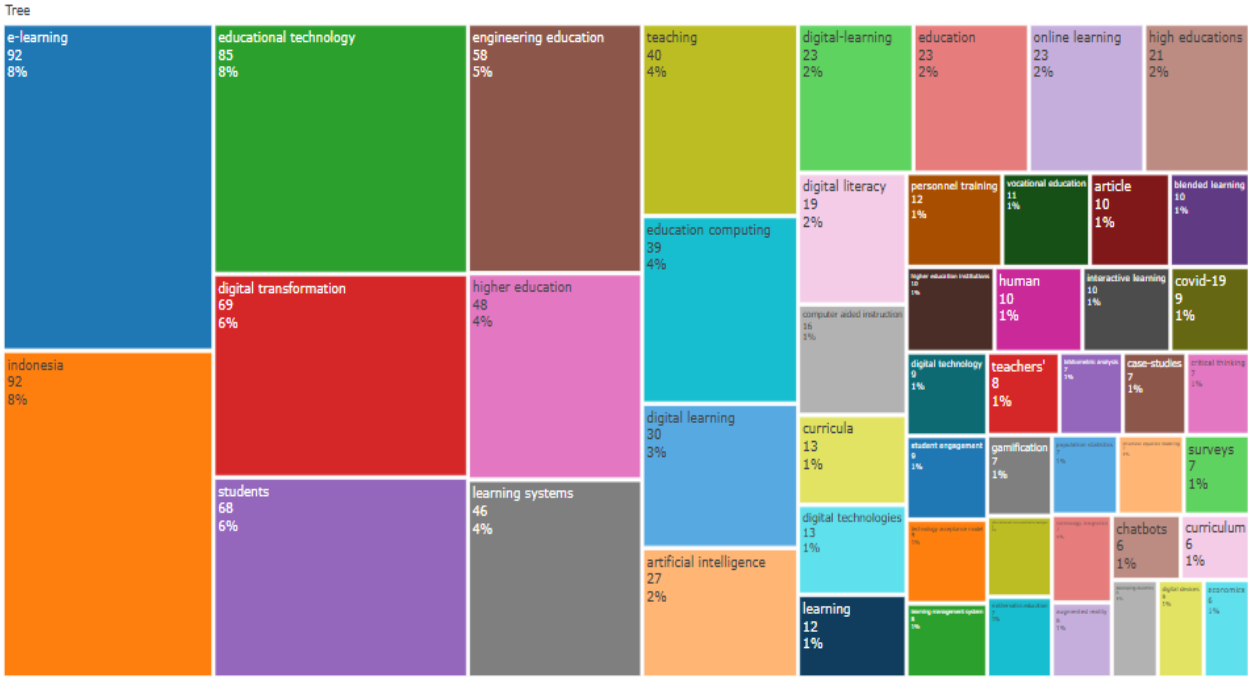


Figure 5. Thematic Distribution of Digital Transformation Research in Indonesian Education
Source: Processed bibliometric data from Scopus database using Biblioshiny (2026).

Research Focus on Digital Transformation Studies in Indonesian Education

The keyword co-occurrence network analysis illustrates the evolving research focus and intellectual structure of digital transformation studies in Indonesian education. The visualization reveals several interconnected thematic clusters, indicating that research in this field is highly interdisciplinary and collaborative. Dominant themes such as digital transformation, educational technology, e-learning, engineering education, learning systems, online learning, and digital learning appear as central nodes with strong interconnections, demonstrating their significant role in shaping the research landscape. The red cluster mainly focuses on digital transformation, education, digital literacy, blended learning, and learning models, reflecting increasing scholarly attention toward pedagogical innovation and educational adaptation in digital environments. The green cluster emphasizes digital learning, higher education, mobile learning, technology integration, and self-efficacy, indicating growing concern for learner engagement and digital learning ecosystems. Meanwhile, the blue cluster is closely associated with online learning, engineering education, learning management systems, and digital technologies, suggesting strong relationships between technological infrastructure and instructional systems. Emerging themes such as artificial intelligence, gamification, augmented reality, virtual learning environments, and technology acceptance models further indicate the diversification and increasing sophistication of digital transformation research in Indonesian education. Overall, the network visualization demonstrates that the research focus has shifted from basic ICT integration toward broader discussions involving digital pedagogy, adaptive learning environments, institutional transformation, and sustainable educational innovation.

Figure 6. Research Focus and Keyword Co-Occurrence Network in Digital Transformation Research in Indonesian Education

Emerging Opportunities and Future Research Frontiers in Digital Transformation of Indonesian Education

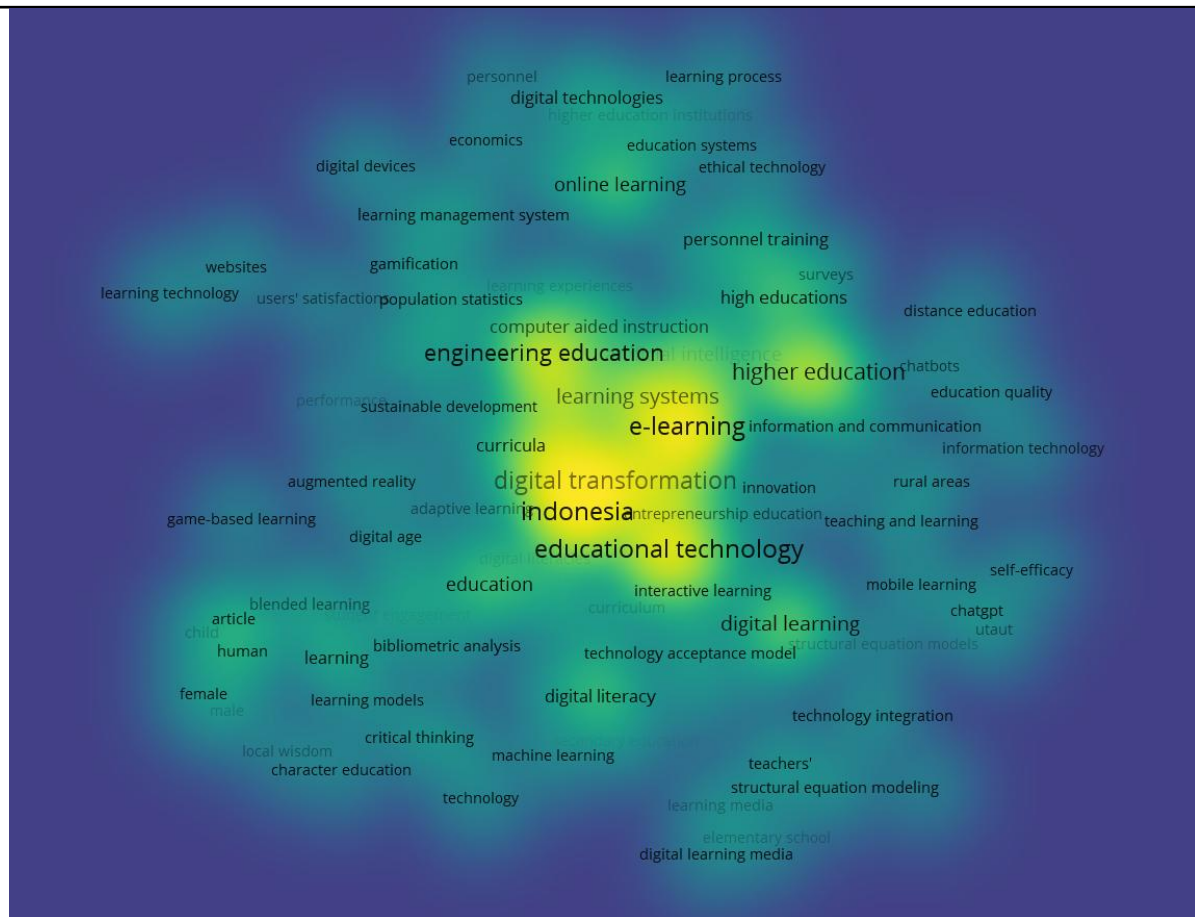


Figure 7. Opportunities and Novelties for Future Research in Digital Transformation Research in Indonesian Education

Source: Processed bibliometric data from Scopus database using VOSviewer (2026

Discussion on Digital Transformation in Indonesian Education

The findings of this study reveal that digital transformation has evolved into one of the most dynamic and rapidly expanding research domains within Indonesian education. The substantial increase in scientific publications after 2020 demonstrates how the COVID-19 pandemic accelerated the digitalization of teaching, learning, and educational governance across schools and higher education institutions in Indonesia. Prior to the pandemic, educational technology discussions in Indonesia were primarily limited to information technology integration, online learning experimentation, and learning management systems. However, the pandemic transformed digital technology from a supplementary educational tool into a strategic necessity for ensuring educational continuity and institutional resilience (Pramana et al., 2020). This shift explains the significant increase in publication trends and the emergence of increasingly diverse research themes related to digital transformation in Indonesian education.

The dominance of themes such as e-learning, educational technology, online learning, digital learning, and learning systems indicates that Indonesian educational institutions are currently undergoing a transition toward technology-enhanced and student-centered learning environments. The findings suggest that digital transformation in Indonesia is no longer understood merely as the adoption of digital devices or online platforms, but rather as a broader process of educational restructuring involving curriculum adaptation, pedagogical innovation, institutional governance, and digital learning ecosystems. Previous studies have

emphasized that the integration of learning management systems, blended learning models, and flexible instructional systems has become essential for improving educational accessibility, learning flexibility, and institutional adaptability within Indonesian educational contexts (Amin et al., 2023; Habibi et al., 2023).

The keyword co-occurrence analysis further demonstrates that digital transformation research in Indonesian education is becoming increasingly interdisciplinary and conceptually sophisticated. The emergence of themes such as artificial intelligence, adaptive learning, augmented reality, gamification, digital literacy, and technology acceptance models illustrates a transition from conventional ICT integration toward intelligent, personalized, and data-driven learning ecosystems. This finding reflects broader global trends where digital transformation increasingly emphasizes learner engagement, adaptive educational systems, and technology-supported pedagogical innovation (Krath et al., 2021). The growing prominence of artificial intelligence and adaptive learning themes also indicates that Indonesian researchers are beginning to engage with emerging technologies that may fundamentally reshape future educational practices.

From a theoretical perspective, the findings suggest that digital transformation in Indonesian education should be understood not merely as technological adoption, but as a multidimensional transformation involving pedagogy, institutional governance, digital culture, and socio-technical adaptation. The interconnected themes identified through the bibliometric network demonstrate that successful digital transformation depends on the interaction between technological infrastructure, human capability development, institutional readiness, and educational innovation. This finding strengthens socio-technical perspectives emphasizing the inseparable relationship between technology, organizational systems, and human actors in shaping sustainable educational transformation (Anggono et al., 2025). In this context, digital transformation becomes a process of institutional and cultural change rather than simply technological modernization.

The findings also indicate that digital transformation research in Indonesia is still predominantly technology-centered, with greater emphasis on digital platforms and online learning systems than on pedagogical transformation, educational equity, and long-term sustainability. This tendency suggests that digital transformation initiatives in Indonesia may risk becoming technologically driven without sufficiently addressing deeper issues related to curriculum redesign, teacher empowerment, learner well-being, and inclusive educational access. Although technological integration has become increasingly widespread, discussions concerning the quality of digital pedagogy, ethical technology use, digital well-being, and sustainable educational ecosystems remain relatively limited within the current research landscape. Consequently, future digital transformation initiatives should move beyond technology adoption toward more human-centered, context-sensitive, and sustainability-oriented educational approaches.

Another important finding concerns the strategic role of higher education institutions as the primary drivers of digital transformation research in Indonesia. Universities such as Universitas Pendidikan Indonesia, Universitas Sebelas Maret, Universitas Negeri Padang, and several technology-oriented institutions dominate scientific production in this field. This dominance suggests that universities function not only as centers of knowledge production, but also as laboratories for digital experimentation, pedagogical innovation, and educational transformation. The strong collaborative patterns identified through co-authorship analysis further indicate that digital transformation research increasingly requires interdisciplinary and interinstitutional collaboration involving education, technology, engineering, management, and social sciences. Such collaboration is essential because digital

transformation issues involve complex interactions among technological systems, educational governance, institutional culture, and socio-economic conditions.

The Indonesian context also presents unique challenges for digital transformation due to geographical disparities, unequal technological infrastructure, socio-economic diversity, and variations in institutional readiness across regions. As an archipelagic country with substantial disparities between urban and rural areas, Indonesia faces persistent challenges in ensuring equitable digital access and educational transformation. Previous studies have shown that unequal internet infrastructure, limited technological resources, and disparities in teacher digital competence continue to hinder effective digital transformation across Indonesian schools and universities, particularly in rural and underdeveloped regions (Onitsuka et al., 2018; Yaqin et al., 2023). Consequently, digital transformation strategies that may be effective in urban educational institutions are not always directly applicable to rural schools, Islamic boarding schools, or marginalized educational communities with limited digital access and infrastructure.

The emergence of themes associated with digital literacy, self-efficacy, learner engagement, and curriculum transformation further indicates growing recognition that successful digital transformation depends not only on technological availability, but also on the preparedness of teachers, students, and institutions to adapt to rapidly changing educational environments. This finding suggests that digital transformation involves changes in educational culture, learning behavior, and institutional practices rather than simply the implementation of technological tools. In this regard, teacher readiness and digital competence become critical factors influencing the sustainability and effectiveness of educational digitalization efforts in Indonesia.

The visualization of emerging themes also provides important insights into future research opportunities and policy development. Future studies should move beyond technology adoption discussions toward more human-centered and sustainability-oriented perspectives, including ethical artificial intelligence in education, digital well-being, adaptive learning environments, inclusive digital ecosystems, and culturally responsive digital transformation models within Indonesian educational contexts. In addition, greater scholarly attention is needed for digital transformation within primary education, Islamic educational institutions, special education, rural schools, and marginalized communities, which remain relatively underrepresented in the current literature. The findings also imply the need for more equitable digital education policies in Indonesia, particularly regarding infrastructure distribution, teacher digital competency development, curriculum transformation, and sustainable digital learning governance across diverse educational settings. By adopting more inclusive, context-sensitive, and interdisciplinary approaches, digital transformation in Indonesian education may contribute not only to technological advancement, but also to educational equity, institutional resilience, and sustainable educational development.

CONCLUSION

This bibliometric study demonstrates that digital transformation has become a rapidly growing and increasingly influential research domain within Indonesian education, particularly after the COVID-19 pandemic accelerated the adoption of digital technologies across educational institutions. The findings reveal that research on digital transformation in Indonesia is dominated by themes related to e-learning, educational technology, online learning, digital learning systems, and higher education transformation. In addition, the emergence of themes such as artificial intelligence, adaptive learning, gamification, digital literacy, and technology acceptance models indicates that digital transformation research in

Indonesia is evolving toward more sophisticated, interdisciplinary, and innovation-oriented educational ecosystems. The study also highlights the strategic role of Indonesian universities in advancing digital transformation research and demonstrates that collaboration among researchers and institutions has become increasingly important in shaping the development of this field. Overall, the findings suggest that digital transformation in Indonesian education should be understood not merely as technological adoption, but as a multidimensional process involving pedagogical innovation, institutional adaptation, digital culture, and educational sustainability.

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