



The Use of Technology to Improve the Quality of Education by Indonesian Researchers in Scopus Database: A Bibliometric Analysis

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Abstract: This study aims to examine research trends and developments related to the use of technology for improving educational quality by Indonesian researchers through a bibliometric analysis of Scopus-indexed publications. A total of 617 documents were retrieved through a PRISMA-based screening procedure and analyzed using Biblioshiny (R) and VOSviewer. The findings indicate a substantial increase in publication output between 2019 and 2025, reaching its highest level in 2025. Padang State University recorded the highest affiliation occurrence in the dataset, while Habibi Akhmad was identified as the most productive author with the highest local h-index. The International Journal of Emerging Technologies in Learning emerged as one of the leading publication sources, recording the highest local h-index among journals in the dataset. Highly cited publications were predominantly associated with the "Technology Acceptance Model" (TAM). Keyword and thematic analyses revealed the continued prominence of "Educational Technology", "Digital Learning", and "Higher Education". Overlay visualization identified "Machine Learning" and "Digital Competence" as emerging themes, while "Mathematics Education" and "Instructional Design" demonstrated increasing research attention in recent years. These findings highlight the rapid growth and diversification of educational technology research in Indonesia and provide valuable insights for future research and policy development toward achieving quality education.

Keywords: Bibliometric analysis; Education; Indonesia researcher; Technology

Introduction

Education plays a crucial role in shaping the quality of a country's human resources. Education continues to evolve in line with changing times and rapid technological advancements (Akour et al., 2022; Lavicza et al., 2022). Education is a systematic process aimed at improving an individual's knowledge, skills, and character, enabling them to adapt to various global challenges (González-Pérez et al., 2022). Furthermore, education is a key factor in driving a nation's social,

economic, and cultural progress (Artyukhov et al., 2022; Yang et al., 2023). Indonesia is one country that is continually striving to improve the quality of its education (Fauzan et al., 2025; Tanjung et al., 2025).

Indonesia is a developing country with a large population and high socio-cultural diversity (Khusun et al., 2022). Given these conditions, Indonesia faces various challenges in improving the quality of human resources through education (Amelia, 2023; Do et al., 2025). Education in Indonesia continues to evolve in line with global demands and modern advancements

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(Samala et al., 2024; Widiastuti, 2025). However, various obstacles remain, such as disparities in access, quality, and equity of education across regions. Therefore, one relevant solution to improving the quality of education is the use of technology.

Technology is a crucial tool for increasing the efficiency and effectiveness of various aspects of life, including education (Alenezi et al., 2023; Ilyas et al., 2023). Rapid technological advancements have driven transformations in learning methods and access to information (Jaya et al., 2024; Kusuma et al., 2024;

Mhlanga, 2024; Nipan et al., 2024). Indonesia has also experienced significant technological progress in recent years, although disparities remain in some regions. The application of technology in education is also in line with government directives through various policies, such as school digitalization programs (Machmud et al., 2024). The increasingly rapid technological advancements have fueled researchers' growing interest in studying the use of technology in education (Depita, 2024; Maritsa et al., 2021; Martaputri et al., 2025).

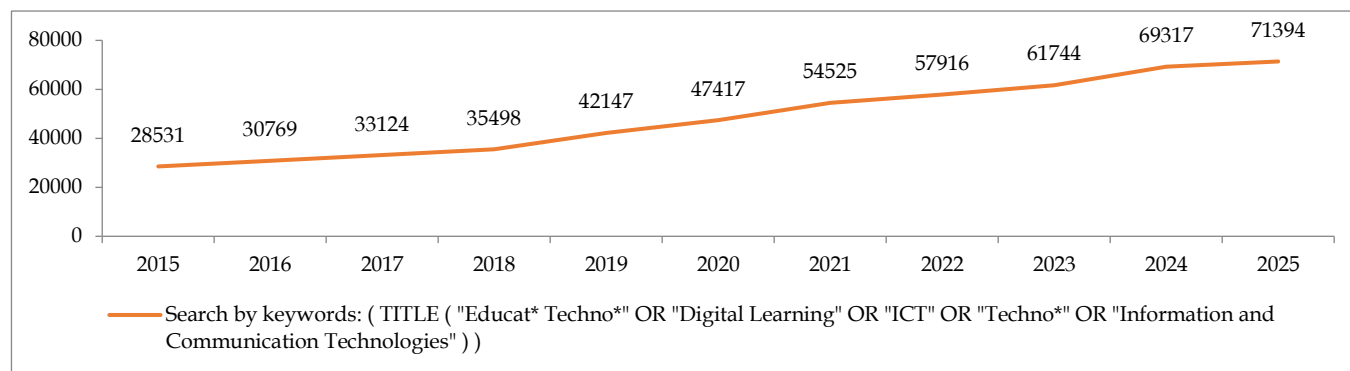


Figure 1. Publication trends regarding technology in general in the scopus database from 2015 to 2025 (Data search in April 2026)

The development of publications on the use of technology in various fields shows a steadily increasing trend. Figure 1 shows that since 2015, the number of publications discussing technology in general has continued to increase until 2025, reaching nearly 72,000 publications, indicating growing global attention to the role of technology in various aspects of life. Furthermore, previous literature has discussed various bibliometric analyses of technology utilization in various contexts, such as auditing, music education, higher education libraries, virtual learning, artificial intelligence, and technology in early childhood education and digital-based learning (Bölükbaş, 2025; Fu et al., 2025; Lai et al., 2025; Lamboglia et al., 2020; Lin et al., 2025; Ma et al., 2025; Makda, 2025; Mitha et al., 2024; Ng et al., 2025; Vinueza-Morales et al., 2025). However, no bibliometric study has specifically and comprehensively mapped the use of technology to improve education quality by Indonesian researchers in the Scopus database.

Using the Scopus database and limiting it to researchers affiliated with Indonesia, this analysis focuses on national contributions to the study of technology utilization in education. This approach allows for a more specific mapping of trends, productivity, and the direction of emerging research in Indonesia. Furthermore, this paper is linked to international literature to examine the interconnectedness and alignment of frequently

researched topics. This allows for an identification of Indonesia's research needs and position within the global context.

Method

Analyze Design

This analysis aims to identify trends, patterns, and developments in research related to the use of technology to improve the quality of education by Indonesian researchers using bibliometric analysis. Bibliometric analysis is a quantitative method used to evaluate and measure the performance of scientific publications based on data such as the number of documents, citations, and keywords (Arthi et al., 2025; Bawack et al., 2022; Chen et al., 2023; Djeki et al., 2022; Donthu et al., 2021; Pranckutė, 2021; Zafrullah & Ramadhani, 2024). This analysis is also used to map the contributions of authors, institutions, publication sources, and dominant research topics in the Scopus database.

Search Strategy

Before conducting the analysis, the author conducted a search using keywords with details in Table 1. The use of keywords in this search was designed to capture publications relevant to the use of technology in educational contexts. The first section used terms such as "Educat* Techno*", "Digital Learning", "ICT",

“Techno*”, and “Information and Communication Technologies” to cover a wide variety of technology-related terms, including derived forms through the use of wildcards (*). Furthermore, combinations with the words “school*”, “learn*”, and “educat*” ensured that

the search results remained focused on the context of education and learning. With this structure, the search strategy became broader yet remained focused in identifying literature relevant to the research topic.

Table 1. Keywords and Search Sources

Source	Keywords
Scopus Database	TITLE (“Educat* Techno*” OR “Digital Learning” OR “ICT” OR “Techno*” OR “Information and Communication Technologies”) AND TITLE (school*) OR TITLE (learn*) OR TITLE (educat*)

Source: Data by author modification

Inclusion and Exclusion Criteria

Details regarding inclusion and exclusion criteria are divided into Table 2. The seven inclusion and exclusion criteria were established to ensure that the analyzed data is relevant, valid, and aligned with the research focus. Topic and discipline-related criteria were used to maintain the appropriateness of the research context, ensuring it remains within the realm of technology-based education. Author affiliations were limited to Indonesia to align with the research’s geographic focus. Furthermore, the use of English and sources from the Scopus database ensured the quality, visibility, and credibility of the analyzed publications. Meanwhile, the restriction on empirical articles and the exclusion of certain types of documents ensured that the data used were truly research-based and not secondary.

Using the criteria in Table 2, the author then analyzed using the PRISMA method. Using the keywords in Table 1, 62,482 documents were obtained in the initial stage, namely Identification. In the screening stage, the author limited the documents to “Social Sciences”, only articles, English language, and only authors affiliated with Indonesia, thus eliminating 61,882 documents, leaving 660 documents. In the eligibility stage, the author manually checked all documents and eliminated 43 documents, leaving 617 documents ready to enter the next stage, namely bibliometric analysis.



Figure 2. Documents selection using PRISMA method (Page et al., 2021)

Table 2. Inclusion and Exclusion Criteria Document Before Bibliometric Analysis

Inclusion Criteria (IC)	Exclusion Criteria (EC)
IC1. The study focuses on the use of technology in the field of education.	EC1. The study does not focus on the use of technology in the field of education.
IC2. The study is conducted within the discipline of education.	EC2. The study is not conducted within the discipline of education.
IC3. The document includes at least one author affiliated with an Indonesian institution.	EC3. The authors are not affiliated with institutions in Indonesia.
IC4. The publication is written in English.	EC4. The publication is not written in English.
IC5. The document type is limited to articles only.	EC5. The document type is not an article, such as conference papers, review articles, book chapters, editorials, or notes.
IC6. The publication is indexed in the Scopus database.	EC6. The publication is not indexed in the Scopus database.
IC7. The study reports empirical research findings.	EC7. The study is non-empirical, such as bibliometric studies, systematic literature reviews (SLR), meta-analysis, or meta-synthesis.

Source: Data by author modification

Documents Analyze

After obtaining the selected documents, the author conducted a bibliometric analysis using R (Biblioshiny) and VOSviewer. The R program was used to analyze the main information, publication trends, affiliations, authors, and the most productive sources. Furthermore, the analysis also included documents with the highest citations, word clouds, and keyword evolution. Meanwhile, VOSviewer was used to map the research focus and keyword novelty.

Result and Discussion

Main Information

The R program aims to analyze the main information in the bibliometric data, such as the number of documents, sources, authors, and publication distribution (Suripah et al., 2025; Zafrullah et al., 2026). Furthermore, this analysis is used to identify underlying patterns in the dataset as a starting point for further analysis.

Main Information analysis from Figure 3 shows that publication growth has a positive trend with an annual growth rate of 13.56%, indicating increasing attention from researchers to this topic from year to year. Furthermore, Indonesia's level of international collaboration is quite high at 26.26%, reflecting the active involvement of researchers in global networks. The average number of authors per document at 4.17, also reinforces the collaborative tendency in producing

scientific publications. Furthermore, the average citation per document, at 8,981 and the document age of 3.59 years, indicate that the publications produced are relatively up-to-date and have a significant academic impact. Overall, these findings confirm that research in this field is developing rapidly, is collaborative, and is beginning to be integrated into the international scientific community.



Figure 3. Main information about technology to improve the quality of education by Indonesia researcher

Publication Trends

This publication trends aims to identify the development and dynamics of research related to the use of technology to improve the quality of education by Indonesian researchers. Furthermore, this analysis helps demonstrate the growth rate, relevance, and increasing attention to this topic in scientific publications (Suripah et al., 2025).

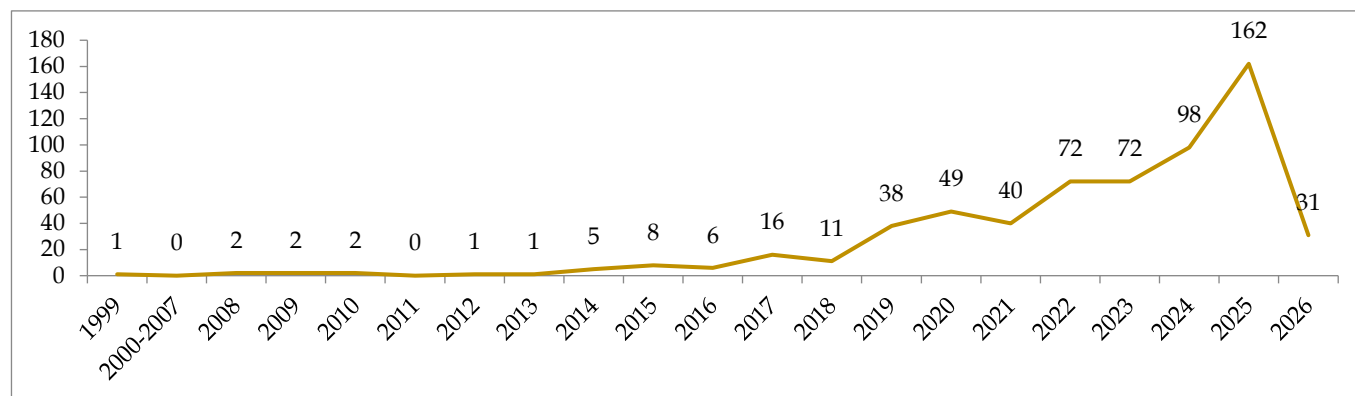


Figure 4. Publication trends from 1999 to 2026 about technology to improve the quality of education by Indonesia researcher

Figure 4 shows that the publication trend fluctuated in the initial period, with a gap in publications in several years, such as 2000–2007 and 2011. The number of publications began to show a more consistent increase starting in 2017, indicating increased attention to this topic. Subsequently, a significant spike occurred, especially in the period from 2019 to 2025, with growth continuing each year. The peak publication rate occurred in 2025 with a total of 162(26.25%) documents, indicating the highest level of productivity during the

observation period. Overall, this pattern indicates a strong acceleration in research development after a relatively stagnant initial phase.

This significant increase is influenced by the accelerated adoption of technology in learning, particularly after the pandemic, which has driven a transformation in the education system. Furthermore, the increasing demand for international publications by Indonesian researchers is also a major driving factor in the increase in publications. However, fluctuations in

the initial period indicate that research development in this field was not previously a top priority. Another issue that requires attention is the potential for unequal access to research resources between institutions. Therefore, strategies that promote equitable distribution of research support, strengthening collaboration, and increasing researcher capacity are needed to ensure this growth trend is sustainable.

The Most Productive Affiliations

The analysis of the most productive affiliations aims to identify institutions that make the most significant contribution to producing scientific publications in a particular field of study (Zafrullah, Ramadhani, et al., 2024). Furthermore, this analysis helps understand the distribution of research productivity and the role of institutions in promoting research development nationally and internationally.

Table 3. Top 10 the Most Productive Affiliations about Technology to Improve the Quality of Education by Indonesia Researcher

Rank	Affiliation	City	Island	Total of Affiliations
1 st	Universitas Negeri Padang	Padang	Sumatra	148
2 nd	Universitas Negeri Yogyakarta	Yogyakarta	Java	120
3 rd	Universitas Negeri Malang	Malang	Java	119
4 th	Universitas Pendidikan Indonesia	Bandung	Java	91
5 th	Universitas Negeri Semarang	Semarang	Java	67
6 th	Universitas Sebelas Maret	Surakarta	Java	60
7 th	Universitas Negeri Jakarta	Jakarta	Java	35
8 th	Universitas Jambi	Jambi	Sumatra	33
9 th	Universitas Negeri Makassar	Makassar	Sulawesi	33
10 th	Universitas Negeri Surabaya	Surabaya	Java	29

Source: Scopus Database

Table 4 shows that the most productive institution outside Java is Universitas Negeri Padang with 148 affiliation occurrences. Although overall, it is still dominated by universities located on Java. Of the top ten affiliates, the majority come from cities in Java, such as Yogyakarta, Malang, Bandung, Semarang, Surakarta, Jakarta, and Surabaya. This finding confirms that Java remains the main center for scientific publication production in Indonesia. This dominance reflects the concentration of resources, infrastructure, and a more established research ecosystem in the region. Thus, the distribution of research productivity across regions remains uneven.

On the other hand, contributions from regions outside Java, such as Padang, Jambi, and Makassar, show growing potential in research activities. This indicates that institutions outside Java are starting to increase their participation in scientific publications.

However, challenges remain, including limited access to funding, collaboration, and research facilities. Therefore, strategies are needed to promote equitable research capacity, such as strengthening cross-regional collaboration and supporting inclusive policies. With these steps, it is hoped that the distribution of research contributions in Indonesia will be more balanced and sustainable.

The Most Productive Authors

The most productive author analysis aims to identify authors who have made the most significant contributions to producing scientific publications in a field of study (Suripah et al., 2025). Furthermore, this analysis helps understand individual productivity patterns and the role of authors in fostering research development and collaboration.

Table 4. The top 10 The Most Productive Authors about Technology to Improve the Quality of Education by Indonesia Researcher

Rank	Author	Affiliation	Islands	h-index	TC ^a	NP ^b
1 st	Habibi Akhmad	Universitas Jambi	Sumatra	9	633	10
2 nd	Mukminin Amirul	Universitas Jambi	Sumatra	7	141	7
3 rd	Herwin	Universitas Negeri Yogyakarta	Java	4	35	4
4 th	Nur Kholifah	Universitas Negeri Yogyakarta	Java	4	60	5
5 th	Farid Muthohhari	Universitas Sarjanawiyata Tamansiswa	Java	4	59	4

a: Total of Citations, b: Number of Publications, Source: Scopus Database & Google Scholar

Table 4 shows that the most productive authors are dominated by several individuals with varying

publication performance and citation impact. The author with the first rank is Habibi Akhmad from Universitas

Jambi with the highest h-index of 9, total citations of 633, and the number of publications of 10. Second place is occupied by Amirul Mukminin, also from Universitas Jambi, with quite significant contributions. Meanwhile, other authors such as Herwin and Nur Kholifah from Universitas Negeri Yogyakarta and Farid Muthohhari from Universitas Sarjanawiyata Tamansiswa also show stable productivity. The differences in h-index values and total citations indicate variations in the impact and visibility of each author's research.

On the other hand, authors from Java continue to dominate the list of authors. This reflects the relatively more developed research ecosystem in Java compared to other regions. However, the presence of authors from Sumatra, such as those from the University of Jambi, indicates that contributions from outside Java are also

starting to be significant. Therefore, authors are expected to further enhance collaboration, both between institutions and across regions, to strengthen the quality and reach of research. Furthermore, increased productivity and citation impact can be achieved through publication in reputable journals and strengthening international research networks.

The Most Productive Sources

The most productive source analysis aims to identify the journals or publication sources that contribute the most to a field of study. Furthermore, this analysis helps understand the distribution of publications and the role of these sources in disseminating and developing research.

Table 5. Top 10 the Most Productive Source about Technology to Improve the Quality of Education by Indonesia Researcher

Rank	Journal	Country	h ^a	TC ^b	NP ^c	SQ ^d
1 st	International Journal of Emerging Technologies in Learning	Austria	9	535	13	Q2*
2 nd	International Journal of Information and Education Technology	Singapore	9	173	28	Q2
3 rd	Jurnal Pendidikan IPA Indonesia	Indonesia	8	154	11	Q3
4 th	International Journal of Evaluation and Research in Education	Indonesia	7	170	14	Q3
5 th	TEM Journal	Serbia	7	143	16	Q3
6 th	APTISI Transactions on Technopreneurship	Indonesia	5	134	9	Q3
7 th	European Journal of Educational Research	Netherlands	5	73	6	Q2
8 th	Frontiers in Education	Switzerland	5	42	7	Q1
9 th	International Journal of Scientific and Technology Research	India	5	49	15	Q4
10 th	Journal of Education and Learning	Indonesia	5	49	10	Q3

a: h-index, b: Total of Citations, c: Number of Publications, d: Scopus Quartile, *: Discontinued Scopus

Table 5 shows that the journal with the highest contribution is the International Journal of Emerging Technologies in Learning with an h-index of 9 and a total of 535 citations, although its number of publications is not the highest. Meanwhile, the International Journal of Information and Education Technology recorded the highest number of publications (28 documents), indicating higher productivity despite lower citations. In general, there is a dominance of journals from the Southeast Asian region, particularly Indonesia, such as the Indonesian Journal of Science Education and the International Journal of Evaluation and Research in Education. This indicates that Indonesian researchers tend to publish their work in journals within a closer regional area. Furthermore, the distribution of quartiles, dominated by Q2 and Q3, indicates that most publications are at the middle level of international indexing.

This phenomenon is influenced by accessibility, appropriate research focus, and the relatively higher acceptance rate for regional journals, particularly Indonesian journals. Furthermore, institutional policies

encouraging publication in indexed journals have contributed to the increasing number of publications in these journals. However, this also presents a challenge for Indonesian journals to continuously improve their quality to compete globally, particularly to achieve a higher quartile. Therefore, journal managers need to strengthen the quality of their editorial processes, improve article selection standards, and expand international collaborations. In this way, Indonesian journals are expected to enhance their reputation and competitiveness in global scientific publications.

Documents with the Highest Citations

The analysis of documents with the highest citations aims to identify publications with the greatest influence in a field of study based on the number of citations (Istiawanto et al., 2024). Furthermore, this analysis helps understand the contribution of scientific works to the development of science and the research directions considered important by the academic community.

Table 6. Top 5 Documents with the Highest Citations about Technology to Improve the Quality of Education by Indonesia Researcher

Rank	Citations	Title	Source	TC ^a	SQ ^b
1 st	(Al-Adwan et al., 2023)	Extending the technology acceptance model (TAM) ... learning platforms	Education and Information Technologies	481	Q1
2 nd	(Huda et al., 2018)	Big data emerging technology: ... online learning resources	International Journal of Emerging Technology in Learning	214	Q2*
3 rd	(Lee et al., 2019)	Affective variables ... communicate in a second language	Australasian Journal of Educational Technology	192	Q1
4 th	(Prasetyo et al., 2021)	Determining Factors ... and DeLone & McLean IS Success Model	Sustainability	135	Q1
5 th	(Persada et al., 2019)	Understanding the Generation Z .. Approach	International Journal of Emerging Technologies in Learning	105	Q2*

a: Total of Citations, b: Scopus Quartile, *: Discontinued Scopus

Analysis of the most highly cited documents in Table 6 shows that the top publication focused on the Technology Acceptance Model (TAM), with a total of 481 citations, was published in the journal *Education and Information Technologies* (Q1) (Al-Adwan et al., 2023). This high number of citations indicates that the topic related to expanding the Technology Acceptance Model (TAM) in the context of metaverse-based learning has a significant influence in this field. Furthermore, the study's focus on the adoption of new technologies in education is a key factor in the research's high relevance. This publication also emphasizes the importance of a strong theoretical approach in explaining user behavior toward digital innovation. Therefore, this article serves as a primary reference in understanding the direction of current research developments.

Overall, the highly cited documents in this table primarily discuss technology acceptance, digital learning, and the integration of theoretical models such as TAM, UTAUT, and information success systems (Huda et al., 2018; Lee et al., 2019; Persada et al., 2019; Prasetyo et al., 2021). These topics demonstrate that research in this area focuses on how technology is adopted and utilized in the learning process. Furthermore, most publications are indexed in highly reputable journals, including several Q1 journals such as the *Australasian Journal of Educational Technology* and *Sustainability*. This demonstrates that research contributions in this field have achieved an internationally recognized level of quality. The presence of Q1 journals also strengthens the validity and scientific impact of the research produced.

Therefore, future authors are advised to read and use these highly cited documents as primary references in developing their research. Understanding the theoretical frameworks used, such as TAM and UTAUT, can assist in designing more robust and relevant research. Furthermore, authors need to identify underexplored research gaps to generate more innovative contributions. Efforts to publish research

results in highly reputable journals also need to be increased to achieve greater citation impact. This will significantly improve the quality and influence of future research.

Word Cloud

Word cloud analysis focuses on identifying the most frequently researched keywords or topics within a field of study (Oktarina et al., 2025). Furthermore, this analysis helps illustrate dominant research trends and the direction of topic development based on the frequency of word occurrence.

Word cloud analysis shows that the three most dominant keywords are "technology", "higher education", and "ICT". The dominance of "technology" indicates that the primary focus of the research is on the use of technology in learning contexts. Meanwhile, the high occurrence of "higher education" indicates that most research is conducted at the higher education level. The keyword "ict" also reinforces the fact that information and communication technology is a crucial component of the research. Overall, these three keywords represent the primary direction of research focused on technology integration in the context of higher education.

The high frequency of these keywords may be influenced by the rapid development of digital technology, which is driving transformation in the learning system, particularly in higher education. Furthermore, higher education institutions tend to be more prepared to adopt technology than other levels, both in terms of infrastructure and human resources. The widespread use of ICT is also supported by the need for flexible and digital-based learning, particularly in the context of educational globalization. This phenomenon is further amplified by the pandemic, which has accelerated the adoption of technology in the learning process. Thus, the dominance of these keywords reflects research responses to the changing needs and dynamics of modern learning.



Figure 5. Word cloud analysis about technology to improve the quality of education by Indonesia researcher

Keyword Evolution

Keyword evolution analysis aims to identify changes and developments in research topics over time

within a field of study. Furthermore, this analysis helps understand shifts in research focus and the emergence of relevant new trends and themes.

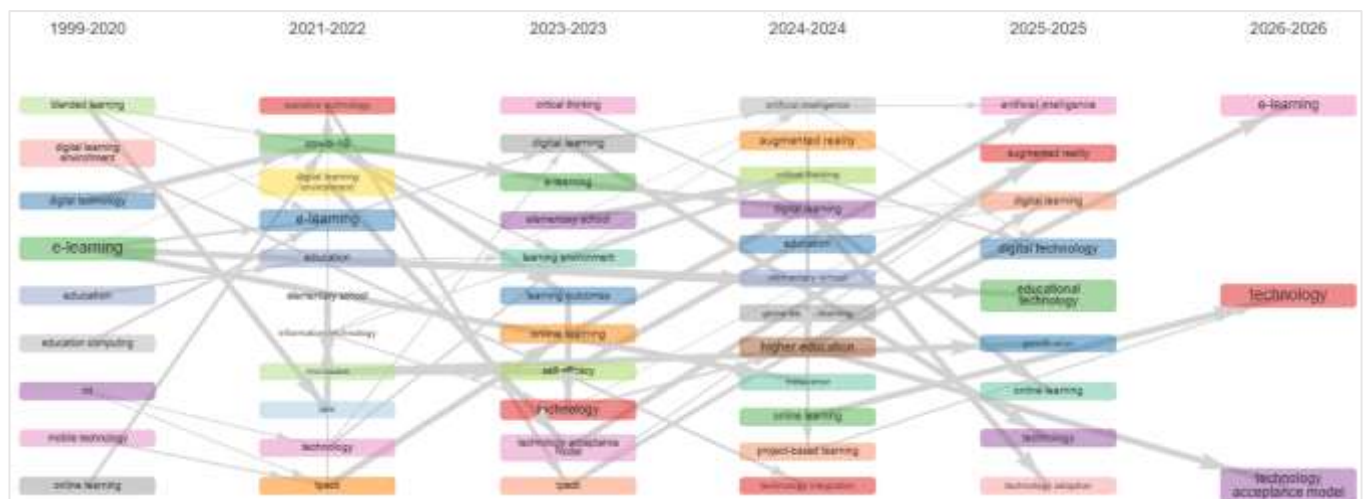


Figure 6. Keyword evolution about technology to improve the quality of education by Indonesia researcher

Keyword evolution analysis reveals a number of keywords that consistently appear across various research periods, such as "technology", "e-learning", "online learning", and "TPACK". This consistency indicates that the use of technology to improve the quality of education by Indonesian researchers is a core theme that continues to develop and is ongoing. Furthermore, the relatively high stability values for several keywords indicate a strong correlation across time periods in this study. This indicates that the

research has a fairly solid conceptual foundation for integrating technology into learning practices. Thus, consistent keywords reflect the primary focus in efforts to improve the quality of technology-based education.

On the other hand, there are also keywords that have begun to disappear or are no longer relevant in subsequent periods, such as "educational computing", which is no longer dominant in recent studies. This indicates a shift from a more general technological approach to a more specific and contextual one.

Technological developments and increasingly complex educational needs are driving changes in research focus. In this context, Indonesian researchers are tending to abandon outdated, less relevant terms and shift to more sophisticated concepts. Thus, the missing keywords reflect the dynamics of research developments in improving the quality of education.

Furthermore, keywords experienced transitions between periods, such as the shift from “blended learning” to “covid-19” and from “ICT” to “technology.” These transitions demonstrate that research is highly responsive to changing global conditions, particularly the impact of the pandemic on the education system. Furthermore, these shifts reflect the evolution of approaches to increasingly broad and complex technology utilization. In the context of improving the

quality of education, these changes demonstrate an adaptation to the needs of more flexible and digital-based learning. Therefore, authors need to pay attention to keyword evolution to understand the direction of research development and produce more relevant contributions.

Focus Research

Focus research analysis using VOSviewer aims to identify key topic clusters and the relationships between keywords within a field of study (Ayuni et al., 2024). Furthermore, this analysis helps map the research structure, allowing for a visual and systematic understanding of the direction, concentration, and development of research focus.

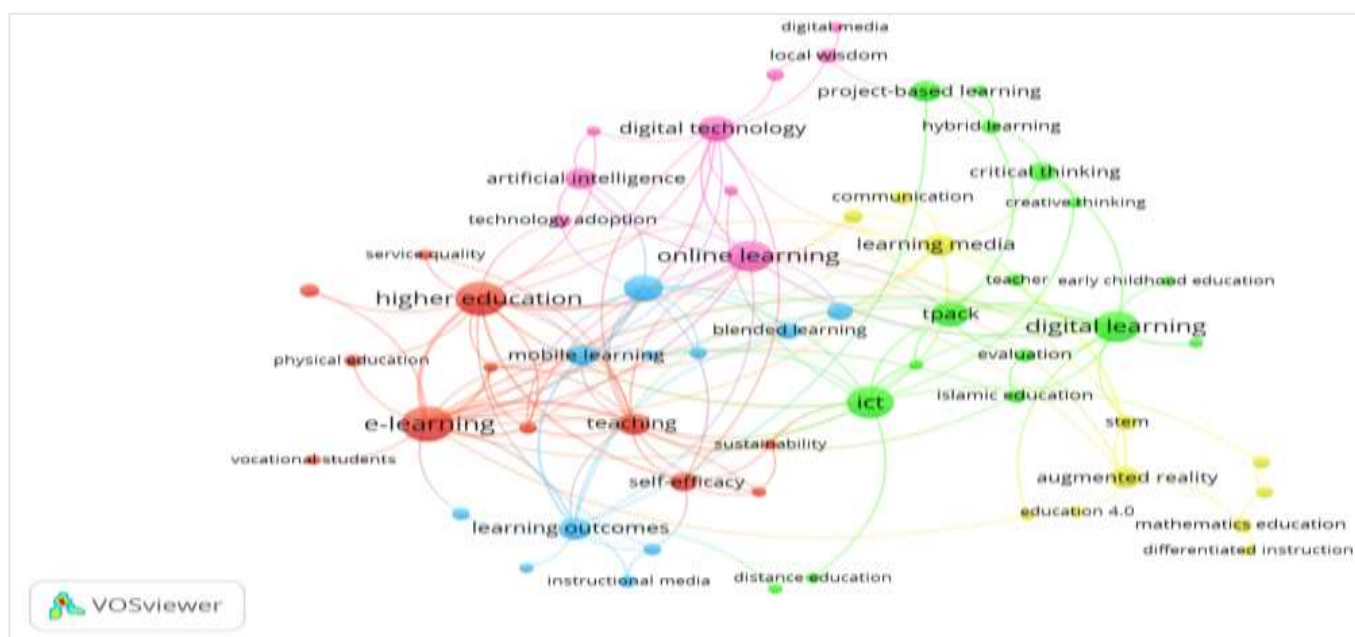


Figure 7. Focus research about technology to improve the quality of education by Indonesia researcher

Using keyword occurrence ≤ 3 , we obtained 59 keywords divided into 5 clusters. The author then gave names according to the clusters, as can be seen in Table 7. The green cluster “Pedagogical Innovation Ecosystem”, focuses on integrating learning practices, strengthening educator competencies, and developing adaptive and innovative learning environments across various levels of education. This cluster reflects how pedagogical approaches continue to evolve in line with the need for more creative, reflective, and experiential learning. Furthermore, its broad context demonstrates the application of learning innovations across various levels and types of education. Meanwhile, the red cluster “Computational Learning Advancement”, focuses on the use of computational approaches and intelligent systems to support the learning process. This cluster illustrates the integration of computing technology to

improve the effectiveness, efficiency, and quality of learning across various educational contexts.

The blue cluster “Adaptive Learning Experience Design” focuses on developing personalized, interactive, and learner-centered learning experiences. This cluster highlights how learning design can be tailored to individual needs and encourage independent learning through a more flexible approach. Furthermore, this cluster illustrates the importance of user-system interaction in creating effective learning experiences. Meanwhile, the yellow cluster “Future-Oriented Instructional Framework” focuses on developing future-oriented learning models and frameworks. This cluster reflects the integration of innovative approaches in learning design that support 21st-century skills and readiness for changes in the world of education.

Table 7. Keyword Grouping Based on Keyword Occurrence about Technology to Improve the Quality of Education by Indonesia Researcher

No	Color Cluster	Keywords	Group Name	Description
1 st	Green (16 items/27.11%)	Creative thinking, Critical Thinking, Digital Competence, Digital Innovation, Digital Learning, Distance Education, Early Childhood Education, Evaluation, Hybrid Learning, ICT, Islamic Education, Junior High School, Media, Project-based Learning, Teacher, TPACK	Pedagogical Innovation Ecosystem	Represents integrated instructional practices, competencies, and evolving learning environments
2 nd	Red (12 items/20.33%)	Computer Aided Instruction, Curriculum, E-Learning, Education Computing, Higher Education, Machine Learning, Physical Education, Self-Efficacy, Service Quality, Sustainability, Teaching, Vocational Students	Computational Learning Advancement	Highlights computational approaches, intelligent systems, and performance enhancement
3 rd	Blue (11 items/18.64%)	Assistive Technology, Blended Learning, Digital Literacy, English Language Learning, Instructional Media, Learning Outcomes, Metaverse, Mobile Learning, Problem Based Learning, Self-regulated Learning, Technology Acceptance	Adaptive Learning Experience Design	Focuses on personalized learning experiences, interaction, and learner-centered design
4 th	Yellow (11 items/18.64%)	Augmented Reality, Communication, Differentiated Instruction, Education 4.0, Instructional Design, Learning Media, Mathematics Education, Problem-solving Skills, Senior High School, Social Media, STEM	Future-Oriented Instructional Framework	Reflects forward-looking instructional models and emerging pedagogical structures
5 th	Pink (9 items/15.25%)	Artificial Intelligence, Autonomous Learning, Digital Media, Digital Technology, Game-based Learning, Literacy, Local Wisdom, Online Learning, Technology Adoption	Intelligent Learning Transformation	Captures the shift toward intelligent, automated, and data-driven learning processes

Source: VOSviewer

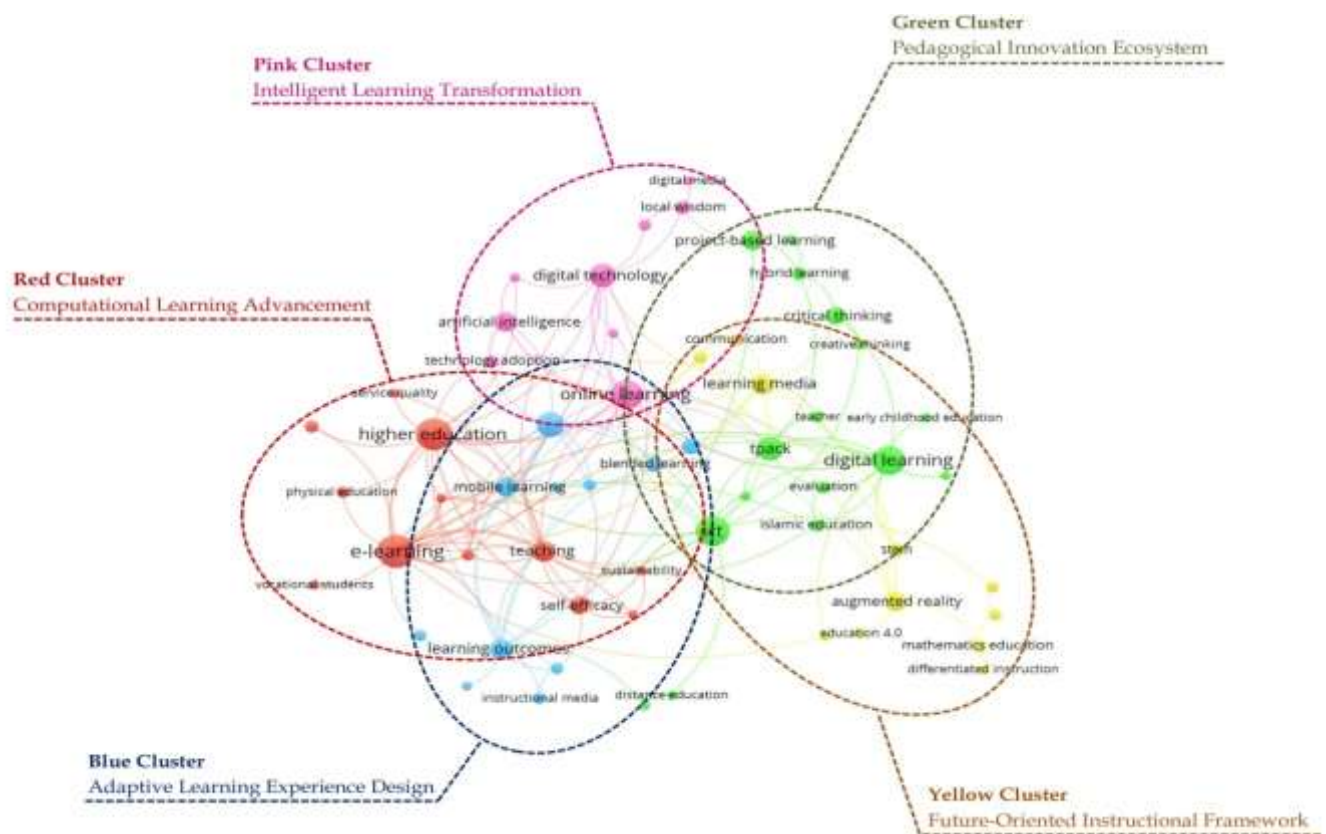


Figure 8. Clustering after given name in VOSviewer

The pink cluster named “Intelligent Learning Transformation” focuses on learning transformation that leads to the use of intelligent systems, automation, and data-driven approaches in the learning process. This cluster reflects the shift toward more independent, adaptive learning, supported by evolving digital innovations. Overall, the five clusters demonstrate a diverse and complementary research focus in understanding the use of technology to improve learning quality. This cluster structure illustrates the progression of research from pedagogical reinforcement

to increasingly complex, intelligence-based learning transformation.

Keyword Novelty

Keyword novelty analysis which uses brightly colored keywords, aims to identify emerging research topics within a field of study (Zafrullah & Ramadhani, 2024). Furthermore, this analysis helps indicate the direction of current research trends and potential innovations that can be developed in future research.

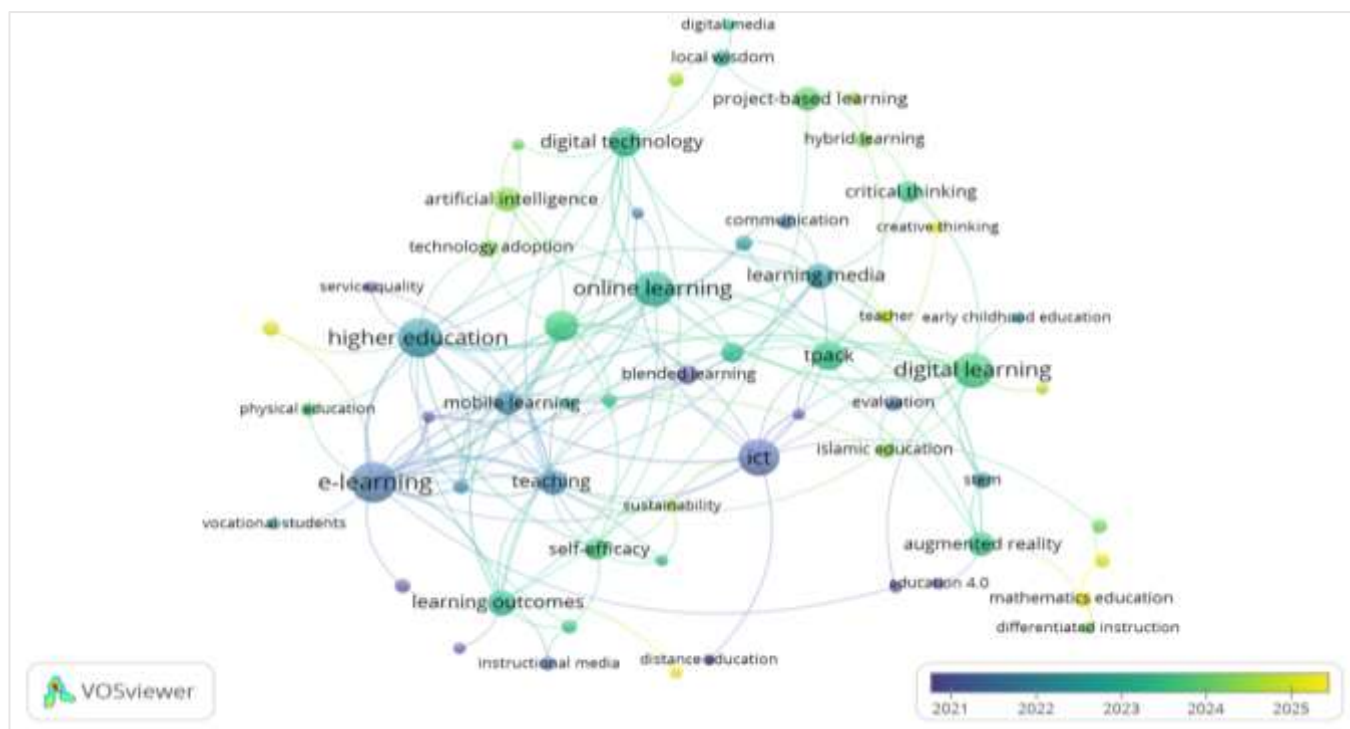


Figure 9. Keyword novelty in VOSviewer about technology to improve the quality of education by Indonesia researcher

Yellow keywords indicate that the topic falls within the latest research category, reflecting the novelty of technology utilization to improve the quality of education by Indonesian researchers. In this analysis, four keywords stand out: “Machine Learning”, “Digital Competence”, “Mathematics Education”, and “Instructional Design.” These four keywords illustrate a research direction that focuses not only on the use of technology but also on how it is optimized within the learning context. This indicates a shift toward a more strategic and quality-based approach to education.

More specifically, “Machine Learning” reflects the use of artificial intelligence to support more adaptive and personalized learning. “Digital Competence” demonstrates the importance of educators’ and students’ abilities to effectively utilize technology to improve the quality of learning. Meanwhile, “Mathematics Education” signifies the application of technology in the context of specific subject areas to

enhance conceptual understanding. “Instructional Design” relates to systematic learning design so that the use of technology can have an optimal impact on learning outcomes, so that all four are interconnected in improving the quality of education.

Overall, the emergence of these yellow keywords indicates that research is beginning to move toward more sophisticated, targeted, and needs-based use of technology. This aligns with efforts to improve the quality of education through the integration of technology, not merely as an aid but also as part of a learning strategy. Furthermore, the interrelationships between these keywords reflect a holistic approach to developing technology-based learning. Thus, these topics serve as important indicators in understanding the direction of new research in improving the quality of education.

Conclusion

The analysis results show a significant surge in publications from 2019 to 2025, with a peak of 162 documents (26.25%) in 2025, indicating a rapid increase in research productivity. The most productive institution outside Java is Padang State University with 148 affiliation occurrences, while the most productive author is Habibi Akhmad from Jambi University with the highest h-index of 9. The prominent publication source is the International Journal of Emerging Technologies in Learning with an h-index of 9, and the document with the highest citations focuses on the Technology Acceptance Model (TAM) with 481 citations. Word cloud analysis and keyword evolution show the dominance and consistency of topics related to the use of technology, digital learning, higher education, and the integration of learning systems that continue to develop sustainably. In addition, mapping using VOSviewer produced 59 keywords in 5 clusters and identified new topics such as “Machine Learning”, “Digital Competence”, “Mathematics Education”, and “Instructional Design” which reflect the direction of increasingly specific and innovative research developments.

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Author Contributions

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Conflicts of Interest

The authors declare no conflict of interest.

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