Research Trends on the Implementation of Digital Literacy in Education: A Biblio-metric Analysis of the Scopus Database

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Research Trends on the Implementation of Digital Literacy in Education: A Bibliometric Analysis of the Scopus Database

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Abstract

This study examines publication trends and research developments in the field of digital literacy in education using bibliometric analysis. A total of 389 documents were retrieved from the Scopus database (2005 to mid-2025) using the keyword Digital Literacy and related educational terms. The PRISMA method was applied to ensure data validity and relevance. The analysis shows a significant increase in publications starting in 2013, peaking in 2023. Universitas Negeri Yogyakarta was identified as the most productive institution, while Indonesia led in publication volume (n=54), although its international collaboration rate remained low (12.85%). Authors from the United States and Indonesia contributed most frequently. The journal "Education and Information Technologies" was found to be the most productive. The most cited articles focused on informal learning, digital generations, and non-formal educational settings. Thematic evolution revealed conceptual deepening and the emergence of multidimensional approaches to digital literacy. Eight keyword clusters were identified, with new topics such as "Artificial Intelligence", "Self-efficacy", "Augmented Reality", and "Inclusive Education" highlighting future research directions. These findings indicate that digital literacy in education now spans technical, pedagogical, affective, and social dimensions. However, this study is limited to the Scopus database and only includes data up to mid-2025. Future research is encouraged to explore digital literacy in specific educational settings such as vocational, out-of-school, and hybrid learning. Additional gaps include teacher competence in AI integration, challenges in inclusive digital learning, and the need for locally relevant digital literacy indicators.

Keywords: 21st century skills, collaborative learning, critical thinking skills, digital literacy, digital technologies in education, remote learning, pedagogical innovation, research evolution.

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1. Introduction

The development of digital technologies has driven major transformations in the global education system. The way individuals learn, access information, and interact in educational spaces has drastically changed thanks to technological advances (Xu et al., 2024; Zhao et al., 2024; Mena-Guacas et al., 2025; Harmadi et al., 2025). The integration of technology in education enables remote and flexible learning while also strengthening the role of teachers and students in an active and collaborative learning environment (Abedi, 2024; Hidayat et al., 2024; Juliani et al., 2021; Reyes et al., 2024) . In many countries, digital education has become one of the keys to improving the competitiveness of 21st-century human resources (Carabregu-Vokshi et al., 2024; Anurogo et al., 2023; Ammar et al., 2024).

Digital literacy has emerged as an essential competency for learners within this context. It includes not only the ability to access information through digital devices but also the skills to understand, evaluate, produce, and use information ethically and responsibly (Aydınlar et al., 2024; Wahyudi et al., 2023; Deschênes, 2024; Gong et al., 2024). In education, digital literacy forms a critical foundation for promoting problem-based, collaborative, and real-world-relevant learning (Ciampa et al., 2023; Morgan et al., 2022; Reddy et al., 2023; Chang et al., 2023). This competency also supports the development of critical thinking, communication, creativity, and adaptability to evolving learning media (Getenet et al., 2024; Zhang & Zhang, 2024; Harmadi et al., 2025; Fazilla et al., 2022; Sharma et al., 2025).

A notable increase in the number of publications on this topic over the last decade reflects growing scholarly interest and highlights its increasing urgency (see Figure 1). Despite this upward trend, a review of previous studies indicates that most existing bibliometric analyses still address digital literacy in a general sense and rarely explore it specifically within the educational context. Recent years have witnessed a significant increase in research on digital literacy in education, reflecting growing awareness of its

urgency. Despite this, a systematic depiction of the research landscape is still lacking. A previous study conducted by Wu et al. (2025) remained general and did not explicitly map the trends of digital literacy research in educational contexts. Other studies concentrated only on online learning (Pachumwon et al., 2025) or relied solely on the Web of Science database up to 2024, limiting their ability to reflect current research dynamics (Butar et al., 2024). Most of these studies also overlooked the interconnections among keywords, publication sources, and global collaborations among authors and institutions.

This study seeks to address those gaps by utilizing bibliometric analysis based on the Scopus database, which offers broader and more multidisciplinary coverage. Bibliometric approaches have proven effective for exploring knowledge development, scientific collaboration, and the evolution of research topics in education and technology (Mohamed Hashim et al., 2022; Tavares et al., 2022; Vlachopoulos, 2021) The method enables quantitative assessment of publication trends, prolific authors, dominant keywords, and the relationships among various elements in the scholarly network (Mena-Guacas et al., 2025; Contrino et al., 2024).
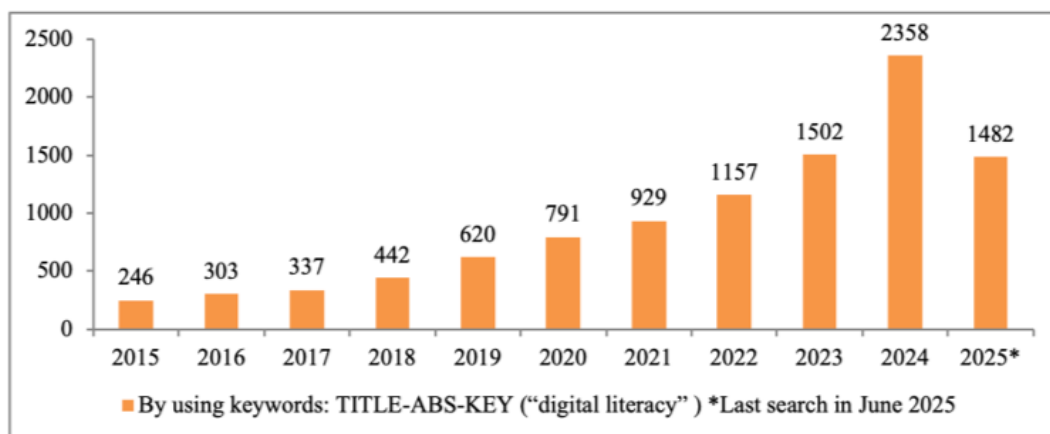

Figure 1. Publication Trends in the Last 10 Years on the Topic of Digital Literacy
(Source: Scopus Database)

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The purpose of this research is to present a comprehensive overview of the development of digital literacy studies in education over the past two decades by answering the following two research questions RQ1. What are the Main Information, Publi-cation Trends, Most productive Affiliates and collaborations between affiliates, Most productive Countries and collaborations between countries, Author Production Over-time, Most Productive Sources, and Highest Cited Documents on the topic of Digital Literacy in Education; RQ2. How is the Evolution of Keywords, Keyword Focus, and Keyword Novelty on the topic of Digital Literacy in Education.

2. Method

a. Research Design

This research will focus on bibliometric analysis of digital literacy in education. Bibliometric analysis is a quantitative method used to systematically review scientific literature with the aim of identifying publication patterns, lead authors, key journals and keyword trends within a field of study (Chen et al., 2023; Passas, 2024) In this context, the analysis was conducted to gain a deeper understanding of the developments, research focus and scholarly contributions that have been made in the field of digital literacy in education.

b. Data Sources and Search Strategies

This bibliometric study was prepared by referring to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines as a framework for transparency in the article selection process (Agrawal et al., 2024). Data were collected on 16 June 2025 through the Scopus database, which was chosen for its broad coverage and credibility in containing reputable scientific publications from various disciplines. A search strategy was developed using a combination of selected keywords applied to article titles, abstracts, and keywords (see Table 1).

Table 1. Search Strings

Database	Search terms
Scopus	TITLE ("digital literacy" AND (learn* OR educat* OR school*)) (LIMIT-TO (DOCTYPE, "ar") AND LIMIT-TO (LANGUAGE, "English") AND LIMIT-TO (PUBYEAR, 2005–2025) AND LIMIT-TO (SRCTYPE, "j") AND LIMIT-TO (SUBJAREA, "SOCI") AND LIMIT-TO (ACCESS_TYPE, "OA"))

c. Article Selection Criteria and Procedure

This study focuses on peer-reviewed, published English-language research articles in the social sciences, specifically those that examine digital literacy in educational contexts. Only studies that presented primary empirical data were included, as such data is critical to exploring the pedagogical opportunities and challenges related to digital literacy in education. Articles written in languages other than English were excluded to maintain consistency of conceptual interpretation and to avoid potential misinterpretation during analysis. In addition, editorials, book chapters, conference proceedings and articles classified as bibliometrics, meta-analysis, scientometrics or systematic literature reviews were also excluded, as they typically do not present primary empirical evidence. The selected articles were indexed in the Scopus database, published from 2005 to 2025, and covered all levels of education. The inclusion (IC) and exclusion (EC) crite-

ria applied in this study are summarized in Table 2.

Table 2. Article selection criteria

Inclusion criteria (IC)	Exclusion criteria (EC)
IC1: Studies with a primary focus on digital literacy.	EC1: Studies that mentioned digital literacy but not as the main research focus.
IC2: Studies conducted at all levels of education.	EC2: Studies in disciplines other than education.
IC3: Articles published from 2005 to 2025	EC3: Articles published before 2005 or after 2025.
IC4: Peer-reviewed research articles.	EC4: Editorials, book chapters and conference papers.
IC5: Articles written in English.	EC5: Articles written in languages other than English.
IC6: Articles indexed in the Scopus database.	EC6: Studies that are not indexed in the Scopus database.
IC7: Studies that present primary empirical data relevant to digital literacy in education.	EC7: Articles categorized as bibliometric, meta-analysis, scientometric, or systematic literature review, as they do not present primary empirical data.

Source: Data Modification by Author

The article selection process follows the four stages in the PRISMA framework, namely: (1) identification, (2) screening, (3) eligibility assessment, and (4) inclusion (Page et al., 2021). In the identification stage, a total of 885 documents were obtained from the Scopus database using structured keywords (see Table 1). After checking through Mendeley, no duplicate documents were found, so all documents proceeded to the screening stage. Screening was conducted by reviewing titles and abstracts based on inclusion and exclusion criteria, resulting in 402 documents for the eligibility assessment stage. At this stage, the metadata and publication information of each document were further examined to ensure the suitability of the document type, article category, and topic focus. As a result, 389 documents met the final criteria and were included in the bibliometric analysis. The flow of article selection is visualized in Figure 2 according to the PRISMA framework.

d. Data Analyze

Data analysis was conducted using a bibliometric approach with the help of Bibliometrix (via the Biblioshiny interface) in the RStudio environment. Biblioshiny facilitates interactive analysis and visualization without the need for manual coding. Data retrieved from the Scopus database was analyzed to generate key indicators, including annual publication trends, prolific authors and institutions, frequently used keywords, core journals, and collaboration networks between countries or affiliations. To enhance network visualization of bibliometric elements such as keywords, authors, and institutions, VOSviewer was also used. Data is exported in CSV format and visualized in VOSviewer based on frequency and strength of links. The integration of Bibliometrix and VOSviewer enables a comprehensive and structured analysis of research trends and scholarly relationships in the field of digital literacy in education.
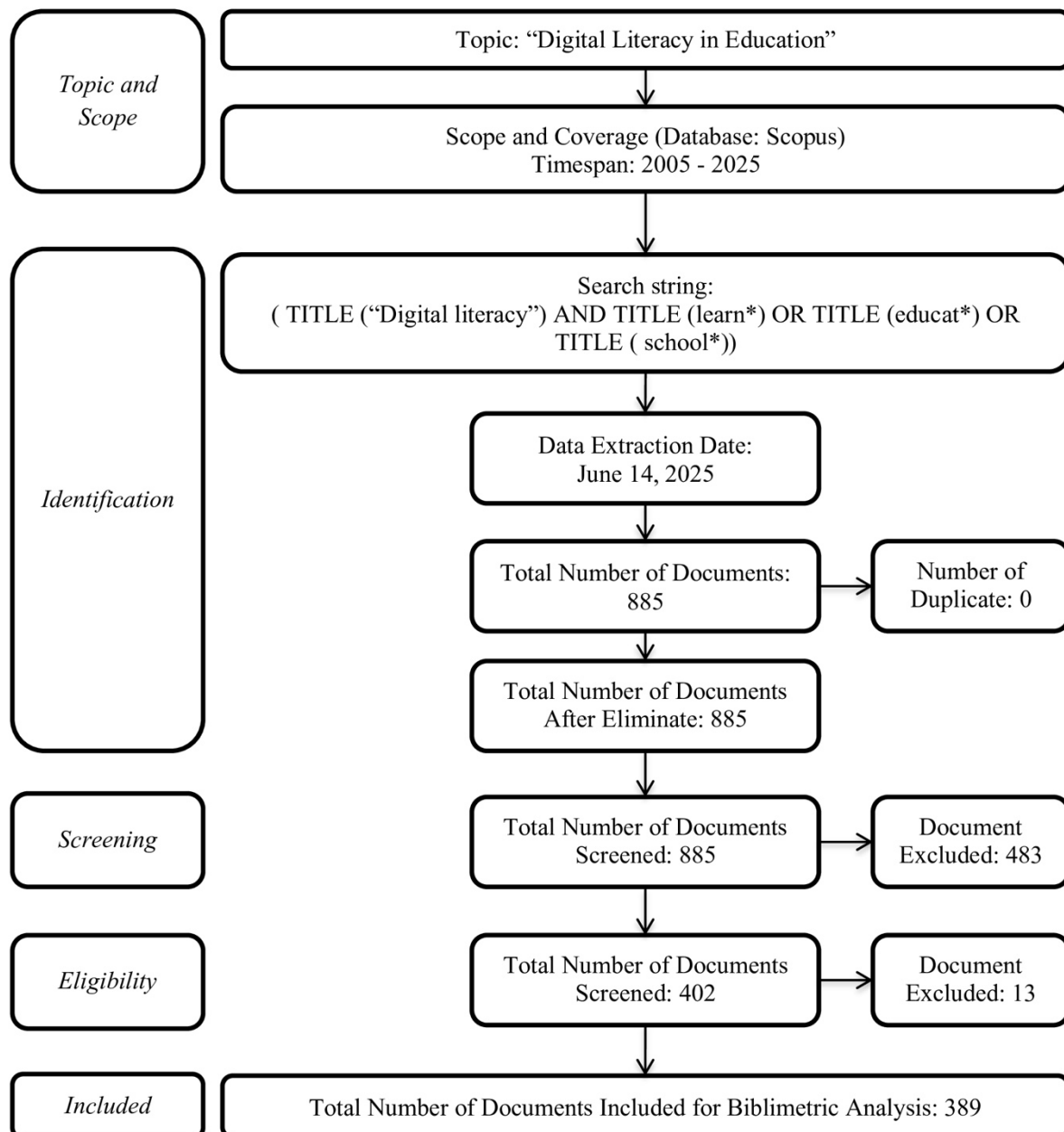
Figure 2. Document Selection with the PRISMA Method for Bibliometric Analysis
(Source: Page et al, (2021))

3. Result and Discussion

Findings based on RQ1: main publication, annual trends, the most productive academic affiliations and their collaborative networks, the most productive countries and patterns of international collaboration, author productivity over time, the leading publication sources, and the most frequently cited documents.

a. Main Information

The main information features in Program R present preliminary summary statistics of bibliometric data, such as the number of documents, authors, citations, publication trends, and most productive sources and affiliations. This analysis helps researchers understand the general landscape of digital literacy research in education and provides a basis for exploration of emerging themes.

Table 3. Main Information

Timespan	2005:2025
Sources (Journals, Books, etc)	232
Documents	389
Annual Growth Rate %	20.97
Document Average Age	4.2
Average citations per doc	19.36
References	17976
Keywords Plus (ID)	376
Author's Keywords (DE)	1167
Authors	1073
Authors of single-authored docs	69
Single-authored docs	74
Co-Authors per Doc	2.92
International co-authorships %	12.85
Article	389

The analysis reflects the development and characteristics of scientific publications on digital literacy in education with a total of 389 documents recorded from 232 Scopus sources from Q1 to Q4. The high annual growth rate of 20.97% indicates that researchers' interest in the topic is consistently increasing. The total number of references used in all documents reached 17,976, illustrating the breadth of literature review used by the researchers. There were 376 Keyword Plus (ID) and 1,167 Author's Keywords (DE) used in the documents, demonstrating the diversity of themes and approaches. There were 1,073 contributing authors, of which 69 were single-authored and produced 74 documents individually. The average number of authors per document was 2.92, reflecting the dominance of team collaboration in the writing process. The percentage of international collaboration reached 12.85%, indicating that there was limited international involvement. This growth reflects a heightened recognition of digital literacy as a core component of 21st-century education. The upward trajectory underscores the urgency for educators and policymakers to integrate digital literacy into curricula and training programs.

b. Publication Trends

Trends in the number of publications were analyzed to see the development of research intensity from year to year . This analysis provides an overview of the increasing scientific interest and attention to the topic of digital literacy in education.
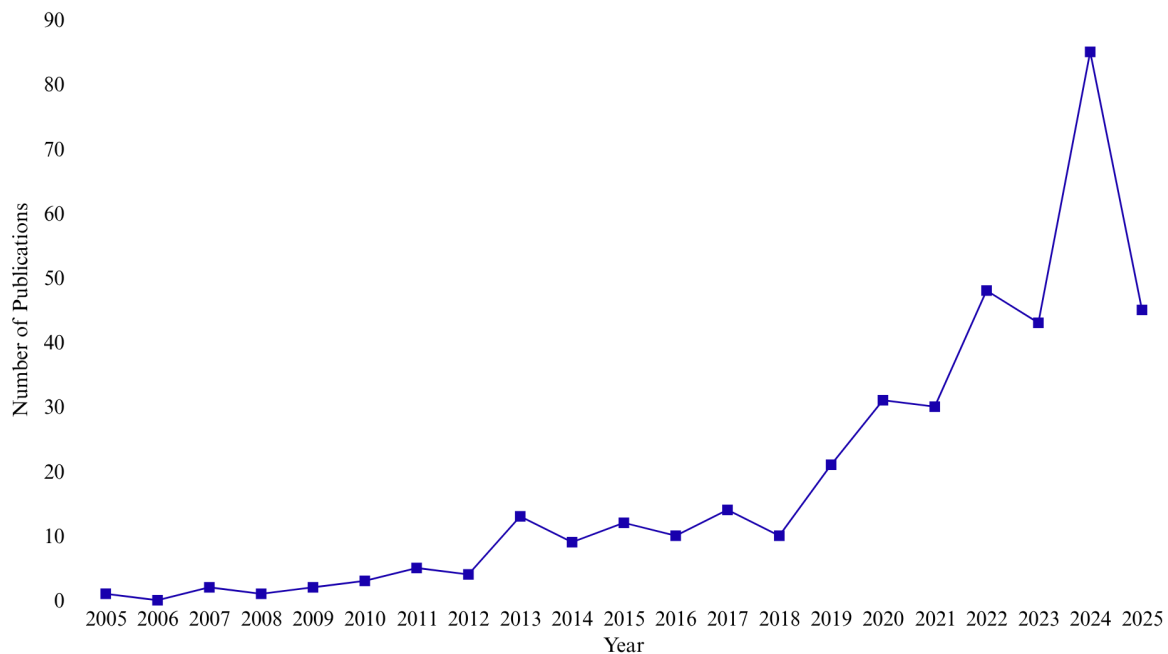
Figure 3. Year-to-Year Publication Trends in the Field of Digital Literacy in Education

The trend of digital literacy publications in education shows three main phases: an early phase (2005–2012) with very low productivity (<5 publications/year), a moderate growth phase (2013–2018) marked by gradual increases, and a rapid expansion phase (2019–2025) with a sharp spike in the number of publications. The peak occurred in 2024 with 85 documents (21.9% of the total). The sharp spike after 2019 was most likely triggered by the COVID-19 pandemic, which accelerated the digitalization of learning and positioned digital literacy as a key competency in the education system. In addition to reflecting volume growth, this pattern also indicates a global paradigm shift from conventional approaches to technology-based education systems. These findings emphasize the urgency of strengthening digital literacy both in the academic realm and in education policy.

The low number of publications between 2005–2010, including zero publications in 2006, reflects that digital literacy was not yet positioned as a strategic agenda in global educational research at that time. However, the sharp increase in the last decade indicates a paradigm shift, from a focus on traditional pedagogy to the integration of technology and digital skills. This increase cannot be separated from the crucial role of the COVID-19 pandemic, which has driven massive adoption of technology in learning and accelerated the need for digital literacy competencies. Thus, publication trend data not only illustrates the increasing academic interest but also reflects the global pressure for digital-based educational transformation in response to the challenges of the 21st century.

c. The Most Productive and Collaboration Affiliations

The analysis of productive affiliations aims to identify the most active institutions in digital literacy research in education and to map key centers of scholarly activity that significantly contribute to knowledge and practice development. Additionally, collaboration analysis reveals national and international scientific networks that help strengthen the research ecosystem in this field.

Table 4. The Top 10 Most Productive Affiliates

No	Affiliation	Country	Continent	Publications
1	Universitas Negeri Yogyakarta	Indonesia	Asia	24(6.17%)
2	Universitas Negeri Malang	Indonesia	Asia	20(5.14%)
3	Universitas Pendidikan Indonesia	Indonesia	Asia	17(4.37%)
4	Universiti Kebangsaan Malaysia	Malaysia	Asia	13(3.34%)
5	Universitas Negeri Semarang	Indonesia	Asia	11(2.83%)
6	Monash University	Australia	Australia	10(2.57%)
7	University of Malaya	Malaysia	Asia	10(2.57%)
8	The Open University	United Kingdom	Europe	10(2.57%)
9	Universitas Negeri Makassar	Indonesia	Asia	10(2.57%)
10	Pedagogical University of Cracow	Poland	Europe	7(1.80%)

Source: R Program

Based on the results of the analysis, Universitas Negeri Yogyakarta ranked first as the most productive affiliation with the highest number of publications, namely 24 articles (6.17%). This position shows that the institution is a research center that plays an important role in the development of digital literacy in the context of education. This is followed by Universitas Negeri Malang with 20 publications (5.14%) and Universitas Pendidikan Indonesia with 17 publications (4.37%), which also shows the high research activity in this field in Indonesia. In fourth place is Universiti Kebangsaan Malaysia from Malaysia with 13 publications (3.34%), confirming the active contribution from the Southeast Asian region. Furthermore, Universitas Negeri Semarang ranked fifth with 11 publications (2.83%). Some other universities that also have significant contributions include Monash University from Australia, University of Malaya from Malaysia, The Open University from the UK, and Makassar State University from Indonesia, which each recorded 10 publications (2.57%). The Kraków Pedagogical University from Poland ranked tenth with 7 publications (1.80%).

The dominance of institutions from the Asian region, especially Indonesia and Malaysia, in the top ten most productive affiliates indicates that this region has become a major growth center in digital literacy research in education. Universitas Negeri Yogyakarta is ranked first thanks to its status as one of the best educational campuses, its strategic position as a higher education institution active in technology-based education research, and its success in building a broad national and international collaboration network. This success is also supported by Universitas Negeri Yogyakarta orientation which focuses on digital learning innovation and strengthening digital literacy capacity among teachers and students. Although institutions from Australia and Europe are also present on the list, Asia's dominance confirms that the dynamics of global research are now increasingly centered in developing regions. This pattern of contribution shows a collective effort across countries in responding to the need for digital transformation in education in an inclusive and sustainable manner.

Figure 4. Collaboration Between Affiliates

The figure shows a map of collaboration between countries in digital literacy research in education. Indonesia appears as a dominant collaboration center, with a broad collaboration network with countries such as Malaysia, Iran, South Africa, the Netherlands, and Hungary, indicating Indonesia's strategic role in building international networks. The United States (USA) is also an important actor with strong connections to East Asian countries such as China, Japan, Korea, and Australia, which form their own collaboration clusters. Meanwhile, the United Kingdom, Portugal, and Spain form collaborative networks involving European and South American countries such as Ecuador, as well as several Asian countries such as India. Several groups of countries such as Austria–Czech Republic–Slovakia and Germany–Estonia form their own clusters, but are relatively separate from the main network. This figure shows that global collaboration in digital literacy research remains fragmented, with some countries acting as primary hubs and others still forming regional collaboration networks.

d. The Most Productive and Collaboration Country

The analysis based on the most productive countries and collaborations between countries aims to identify the contribution of each country in producing scientific publications in the field of digital literacy in education. In addition, this analysis helps to understand the pattern of international collaboration networks that can strengthen knowledge exchange and cross-country research development.

Table 5. Top 10 Most Productive Countries

Country	Continent	Articles	%	Total Citation	%
Indonesia	Asia	54	13,9	330	5,6
United States	North America	29	7,5	969	16,4
Turkey	Asia	23	5,9	230	3,9
United Kingdom	Europe	17	4,4	687	11,6
China	Asia	15	3,9	296	5,0
Malaysia	Asia	13	3,3	311	5,3
Australia	Australia	12	3,1	515	8,7
Spain	Europe	12	3,1	337	5,7
Thailand	Asia	11	2,8	135	2,3
Korea	Asia	10	2,6	146	2,5

Source: R Program

The analysis results show that Indonesia is the country with the largest number of publications, namely 54 articles or 13.9% of the total publications, but only produces 330 citations (5.6%), indicating a scientific influence that is still limited globally. In contrast, the United States is in second place in the number of articles (29 articles or 7.5%) but produces the highest citations, namely 969 citations (16.4%), indicating great quality and impact. The United Kingdom (17 articles, 687 citations) and Australia (12 articles, 515 citations) also show high citation ratios, indicating strong scientific influence even though the number of publications is not as much as Indonesia.

Although Asian countries such as Indonesia dominate in terms of the number of publications in the field of digital literacy in education this region still faces significant challenges in achieving global academic visibility and impact. Indonesia for example is the largest contributor in terms of publication volume yet its level of international collaboration remains relatively low at only 12.85 percent. This indicates the presence of struc-

tural barriers such as locally focused research agendas limited access to international funding language constraints and a lack of strong institutional support for cross-border partnerships. Other Asian countries such as Turkey China Malaysia and Thailand also demonstrate high productivity but generally receive fewer citations compared to Western countries highlighting a gap in scientific influence. Malaysia stands out as an exception with a more balanced profile comprising 13 publications and 311 citations indicating its potential as a regional research hub. In contrast institutions in Europe and North America despite producing fewer publications consistently achieve high citation counts. This is supported by their integration into international research networks better access to high-impact journals and the use of English as the primary language of scientific publication. These findings suggest that while Asia is emerging as a key contributor in this field its future academic influence will largely depend on efforts to improve research quality and strengthen strategic international collaborations.
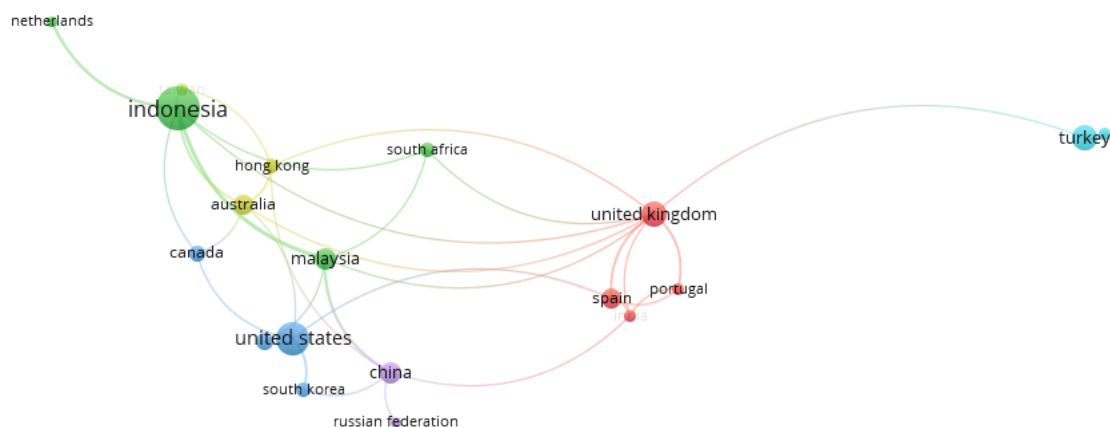

Figure 5. Collaboration Country (Analysis using VOSviewer)

Indonesia appears to be a fairly dominant center of collaboration, establishing research relationships with countries such as Malaysia, Australia, the United States, the

Netherlands, Canada, and South Africa. Strong collaboration is also seen between the United States and Asian countries such as South Korea and China, as well as European

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countries such as the United Kingdom and Spain. The United Kingdom is an important link in the European network, establishing close cooperation with Portugal, Spain, and several other countries. This visualization reflects the existence of quite active international cooperation, especially between Southeast Asian, Western, and European countries, indicating that research on digital literacy has a global and cross-continental reach.

e. The Most Author's Production Over Time

Author production over time analysis aims to identify the productivity of authors over a certain period of time and evaluate the consistency of their contributions to the research topics studied. In addition, this analysis also helps to understand the extent of each author's scientific influence based on the number of publications and citation rates received each year.
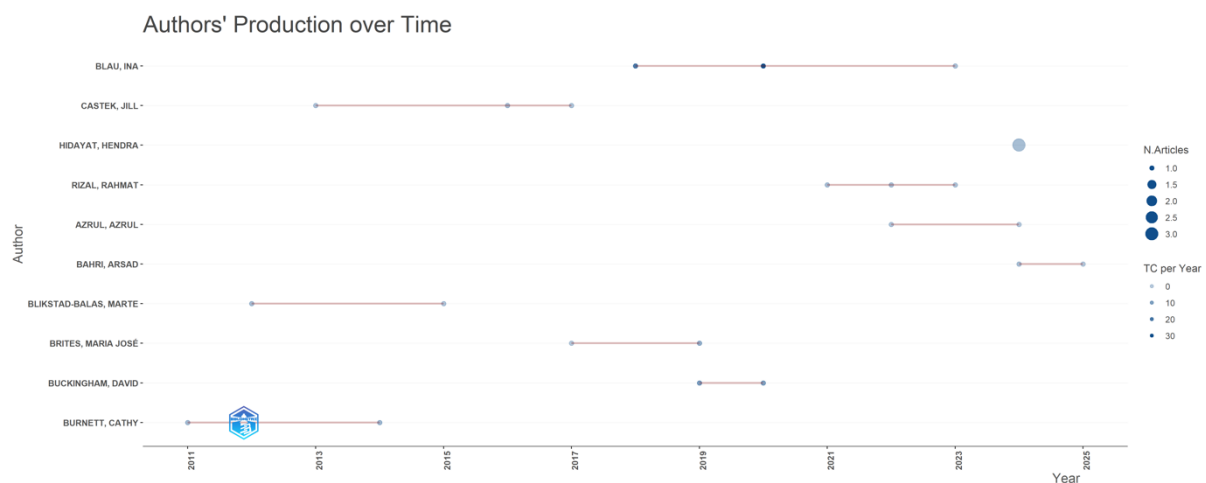

Figure 6. Top 10 Authors Production Overtime (Analysis Using R Program)

Some authors stand out for their productivity and consistency of contribution, such as Jill Castek (University of Arizona) and Ina Blau (The Open University of Israel), who have been actively involved in publications over a long period of time with a relatively stable number of articles. The size of the circles represents the number of articles published by each author, while the color and brightness indicate the average number of citations per year, where darker colors reflect higher academic impact. Hendra Hidayat (Universitas Negeri Padang) is one of the authors with significant contributions in recent years, as seen from the large circle size and dark color indicating strong impact. Meanwhile, other authors such as Rahmat Rizal (Universitas Siliwangi), Azrul Azril,

and Arsad Bahri (Universitas Negeri Makassar) show an increasing trend of involvement in the period 2021–2025. This graph not only illustrates the volume of publications but also provides an understanding of the dynamics of author involvement and the scientific impact they generate over time.

f. The Most Productive Source

The analysis of the most productive sources aims to identify journals or scientific publications that are most often used as a place for disseminating research results on a particular topic, in this case digital literacy in education. The goal is to identify the main container for disseminating knowledge, determine important reference journals, and map publication centers that have a major

influence on the development of science in the field.

Table 6. Top 10 The Most Productive Source

Sources	SQᵃ	Publisher	Country	hᵇ	TCᶜ	NPᵈ
Education And Information Technologies	Q1	Kluwer Academic Publishers	United States	8	346(4.59)	15(3.86)
Journal Of Adolescent And Adult Literacy	Q2	Wiley-Blackwell	United States	5	153(2.03)	7(1.80)
Computers And Education	Q1	Elsevier Ltd	United Kingdom	6	882(11.71)	6(1.54)
Electronic Journal Of E-Learning	Q2	Academic Conferences and Publishing International Limited	United Kingdom	5	235(3.12)	6(1.54)
International Journal Of Emerging Technologies In Learning*	Non Q	International Association of Online Engineering	Austria	6	185(2.46)	6(1.54)
European Journal Of Educational Research	Q3	Eurasian Society of Educational Research	Netherlands	3	43(0.57)	5(1.29)
International Journal Of Instruction*	Non Q	Gate Association for Teaching and Education	Switzerland	5	72(0.96)	5(1.29)
Cakrawala Pendidikan	Q3	Universitas Negeri Yogyakarta	Indonesia	3	50(0.66)	4(1.03)
Computers In The Schools	Q2	Routledge	United States	3	45(0.60)	4(1.03)
Frontiers In Education	Q2	Frontiers Media SA	Switzerland	2	10(0.13)	4(1.03)

*= Discontinued in Scopus as of 2023, a = Scopus Quartile with a focus on "Education", Quartile checked on June 15, 2025, b = h-index, c = Total Citations, d = Number of Publications. (Source: Scopus Database & Scimagojr)

Based on the data, Education and Information Technologies is ranked first as the most productive source, with a total of 15 publications (3.86%) and 346 citations (4.59%) since it first published a related article in 2020. This journal is classified as Q1 quartile and published by Kluwer Academic Publishers in the United States, indicating a high reputation and impact in the field of education and technology. Followed by the Journal of Adolescent and Adult Literacy, which comes from Wiley-Blackwell (USA), with 7 publications (1.80%) and 153 citations (2.03%) since 2016. Meanwhile, Computers and Education, which is also classified as a Q1 journal and published in the UK by Elsevier Ltd., stands out in terms of the very high number of citations, namely 882 (11.71%) even though it only contains 6 pub-

lications (1.54%). This shows that articles from this journal have a very strong academic impact, although the quantity is not as large as other sources. Some other fairly productive journals are the Electronic Journal of E-Learning (235 citations, 6 publications), the International Journal of Emerging Technologies in Learning (185 citations, 6 publications), and the International Journal of Instruction (72 citations, 5 publications), although the latter two are currently no longer listed in the Scopus database since 2023.

Although Indonesia is the country with the highest number of publications in the field of digital literacy in education, only one national journal appears among the most productive sources, and it is ranked in the third quartile (Q3). The absence of Indonesian journals in higher quartiles (Q1 or Q2)

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reflects a broader pattern in which most research outputs by Indonesian scholars are not widely distributed through high-impact, internationally recognized journals. This may be attributed to the limited number of Indonesian journals with international reputation and indexing, as well as a tendency among local researchers to publish in domestically managed journals that are more accessible but have lower global visibility. Furthermore, the international reach and recognition of these local journals are not yet on par with major international publishers that have broader readership and distribution networks. These findings highlight the importance of

developing strategies to improve the quality and indexing status of national journals, while also encouraging Indonesian researchers to target reputable international outlets to enhance the global impact and academic visibility of their work.

g. Document with the Highest Citations

Document with the Highest Citations analysis was conducted to identify the documents most frequently cited by other researchers. This helps highlight works that have a major influence on the development of digital literacy in education.

Table 7. The Top 5 Documents with the Highest Citations

No	Citation	Title	Total Citations
1	(Prior et al., 2016)	Attitude, digital literacy and self efficacy: Flow-on effects for ...	323
2	(Mohammadyari & Singh, 2015)	Understanding the effect of e-learning on individual performance: ...	314
3	(Meyers et al., 2013)	Digital literacy and informal learning ...	271
4	(Greene et al., 2014)	Measuring critical components of digital literacy ...	189
5	(Gui & Argentin, 2011)	Digital skills of internet natives: Different forms of digital literacy in ...	183

Source: R Program

Based on the results of the analysis of documents with the highest number of citations, the two most referenced articles are those that discuss the relationship between digital literacy, attitudes, self-efficacy, and online learning behavior, as well as the role of digital literacy in influencing individual performance in e-learning. The first article received 323 citations, making it the most influential document in this field, while the second article followed with 314 citations. The large number of citations in these two documents indicates that both have made significant contributions in shaping the theoretical framework and practice of implementing digital literacy in the context of technology-based learning.

The five papers analyzed each highlight different dimensions of digital literacy in education. Some focus on informal learning environments and how digital literacy supports non-formal learning, while others emphasize the importance of measuring critical components of digital literacy and their relationship to learning outcomes. Others examine variations in digital skills among secondary school students as a proxy for the digital generation. Despite the different research focuses, these papers collectively make a significant contribution to understanding, measuring, and developing digital literacy as a key element in modern education systems.

None of the top five most-cited documents in the field of digital literacy in educa-

tion originated from Indonesian institutions. This indicates that while Indonesia leads in publication quantity, its contribution to highly influential global literature remains limited. Several factors may explain this gap, including low levels of international collaboration, a tendency to publish in journals with limited global reach, and a lack of strong conceptual or theoretical frameworks in many studies. In contrast, highly cited papers are often published in reputable journals by authors affiliated with institutions that are well integrated into international research networks and academic communities. To enhance the global impact of Indonesian research, it is crucial to improve methodological rigor, target high-visibility publication outlets, and engage more actively in international scholarly collaboration.

After answering RQ1, the next part of RQ2 is Keyword Evolution and Clustering, and Keywords Novelty.

h. Thematic Evolution

Thematic evolution is analyzed with the aim of understanding the development and changes in research focus over time. This analysis does not merely observe the surface of academic publications, but rather seeks to capture how ideas, concepts, and issues evolve in response to scientific progress as well as social, economic, and technological transformations. By examining thematic evolution, researchers are able to trace the continuity of certain topics, the emergence of new themes, and the decline of previously dominant discussions. This process is highly valuable because it provides a clearer picture of how knowledge within a particular discipline is structured and reshaped across different periods. In addition, the analysis helps identify trends that are gaining momentum, dominant issues that require deeper exploration, and possible gaps that could serve as opportunities for further investigation. Ultimately, thematic evolution analysis guides scholars in formulating future research directions more strategically and effectively.
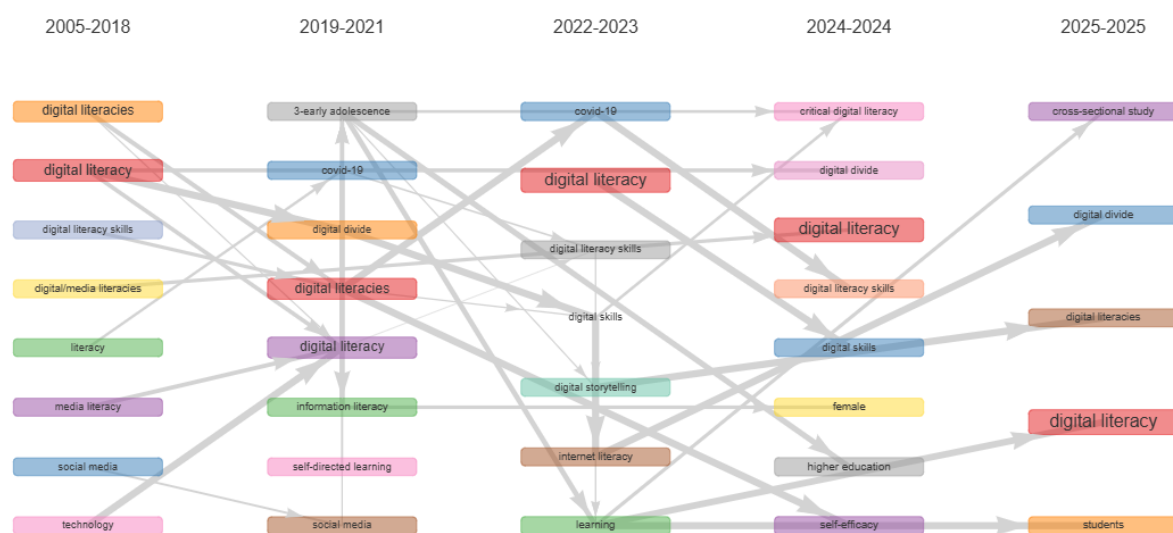

Figure 7. Thematic Evolution During 2005-2025 of Digital Literacy in Education (Field: All Keywords)

The figure shows the thematic evolution of research related to digital literacy in the context of education from 2005 to 2025. In the 2005-2018 period, research still focused on basic concepts such as "digital literacy", "digital literacies", "media literacy", "tech-

nology", 'literacy' and "digital/media literacies". This reflects the initial phase of introducing and understanding digital literacy as part of educational transformation. Entering the 2019-2021 period, the theme began to shift towards more contextual issues such as "covid-19", "digital divide", "self-directed learning", "information literacy", and "social media". These developments show how global conditions such as the pandemic are driving the importance of digital access and capabilities in the self-directed learning process and the emergence of a digital divide is a major concern (Ritonga et al., 2024).

In the period 2022 to 2025, the research topics narrowed down to the application and influence of digital literacy on specific groups or aspects. Keywords such as "digital storytelling", "internet literacy", "learning", "self-efficacy", "higher education", "female", and "students" indicate attention to learning strategies, learner identity and institutional context. In addition, terms such as "critical digital literacy" and "digital skills" emphasize the need for critical thinking skills in dealing with increasingly complex digital information. The emergence of "cross-sectional studies" also marks a more careful methodological approach to examining the phenomenon of digital literacy. Research on digital literacy in education shows a shift from conceptual studies towards practical approaches and focuses on specific contexts and groups within the educational environment.

This thematic evolution reflects a shift from conceptual frameworks toward practical applications aligned with constructivist and experiential learning theories, where learners actively construct knowledge through interaction with digital environments. The emergence of topics such as "self-directed learning" and "digital divide" also suggests a strong link to inclusive and transformative education policies, particularly in response to the COVID-19 pandemic, which accelerated the adoption of remote learning. Educational reforms like Indonesia's Merdeka Belajar and global digital transformation agendas highlight digital literacy as a core 21st-century competency. Therefore, this thematic progression not only captures academic trends but also mirrors policy imperatives that demand greater digital readiness across all levels of education.

i. Focus Research

The analysis of the focus research was conducted because this tool is able to visualize the relationship between keywords in the research network. Thus, researchers can identify the main clusters, central themes, and interrelationships between topics in the analyzed literature.
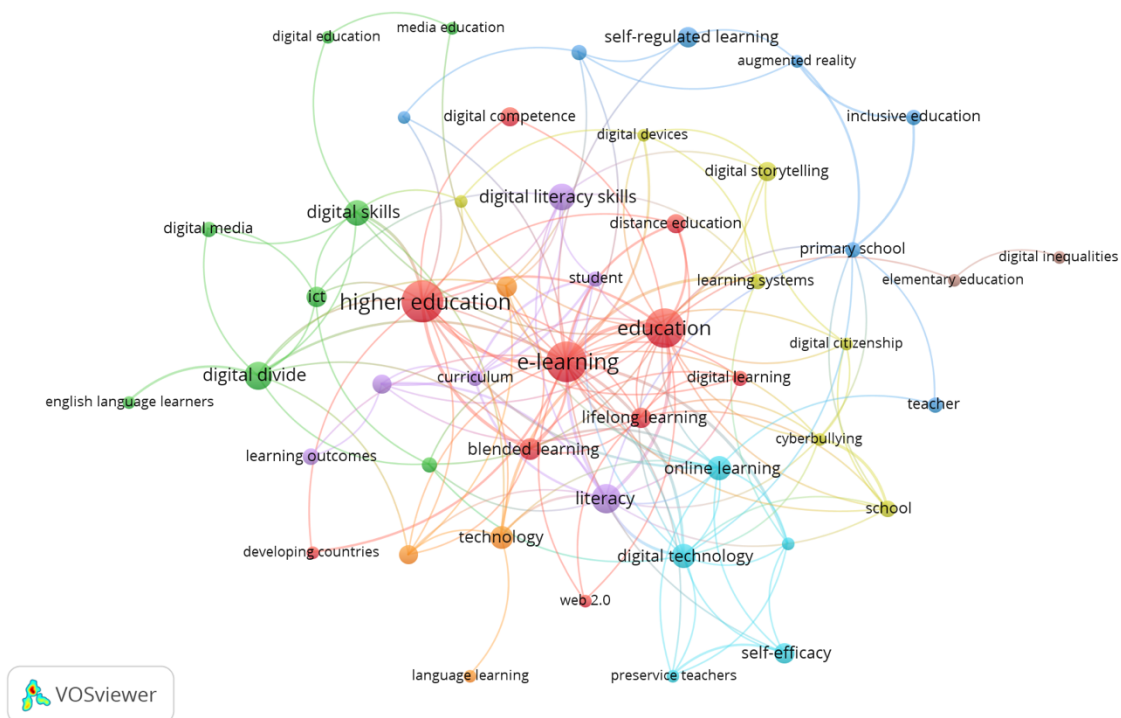
Figure 8. Focus Research (Keyword Occurance ≤ 3)

Based on the analysis using VOSviewer, there are eight main clusters in the research on the topic of digital literacy in education. Cluster 1: "Learning Transformation in the Digital Age" covers topics such as distance learning, lifelong learning and technology integration in higher education, particularly in developing countries. Cluster 2: "Access and Technology Literacy Gap" highlights issues of limited access to technology, basic skills in using digital devices, and challenges faced by English language learners in utilizing digital media. Cluster 3: "Pedagogical Innovation and the New Generation" showcases the latest learning approaches such as the use of augmented reality, self-directed learning, and the role of teachers in the context of learning in primary schools. Cluster 4: "Online Ethics, Tools, and Safety" deals more with the use of digital devices in school settings, learning systems, and social issues such as cyberbullying and the importance of digital citizenship.

Cluster 5: "Smart Technology and Learning Outcomes" explores the linkages between the application of artificial intelligence, curriculum planning and student learning outcomes, including literacy reinforcement. Cluster 6: "Teacher's Role in Online Learning" describes the important role of pre-service teachers and computer-based approaches in supporting effective online learning. Cluster 7: "Learning Independence and Critical Thinking" emphasizes critical thinking skills, language learning, and independence in learning with technology support. Finally, Cluster 8: "Technology Inequality in Basic Education" draws attention to the disparity in access to technology that still exists at the basic education level. Each cluster provides a comprehensive overview of the various dimensions of digital literacy implementation in education.
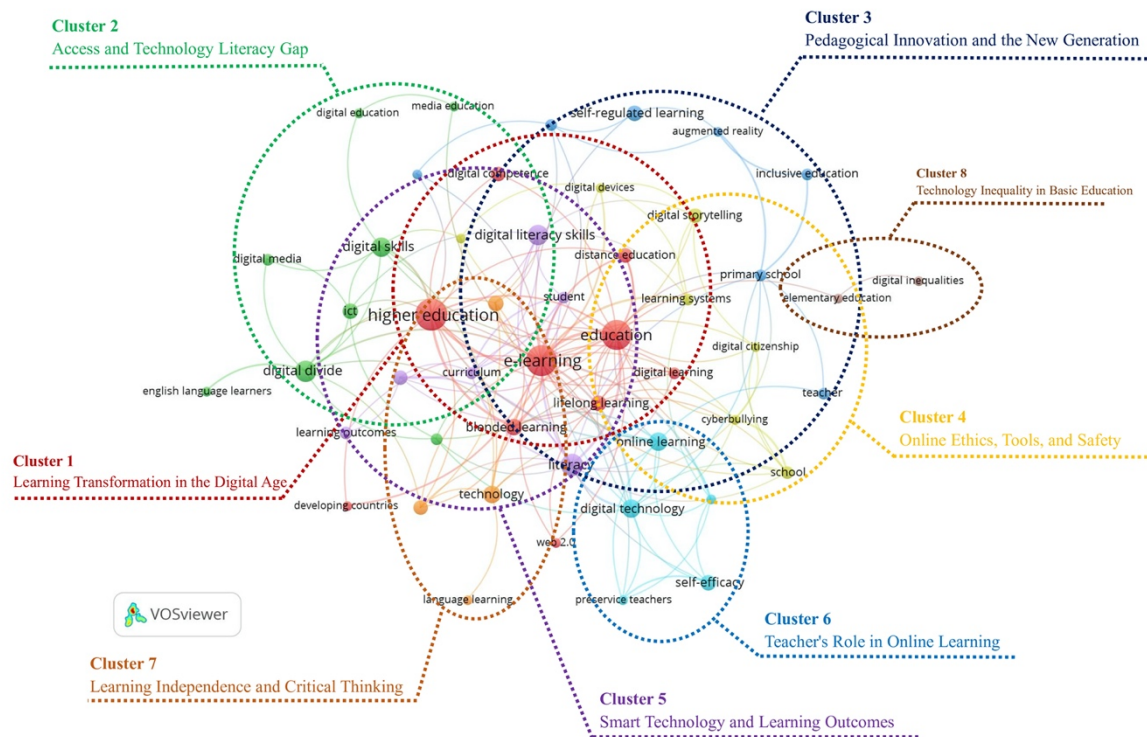
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Figure 9. Clustered Keywords Based on Cluster Colors

j. Keyword Novelty

We used the Overlay Visualization feature to look for novelty in the keywords in the analysis with VOSviewer. Keyword novelty was used to identify emerging trends that are relevant for current and future research.
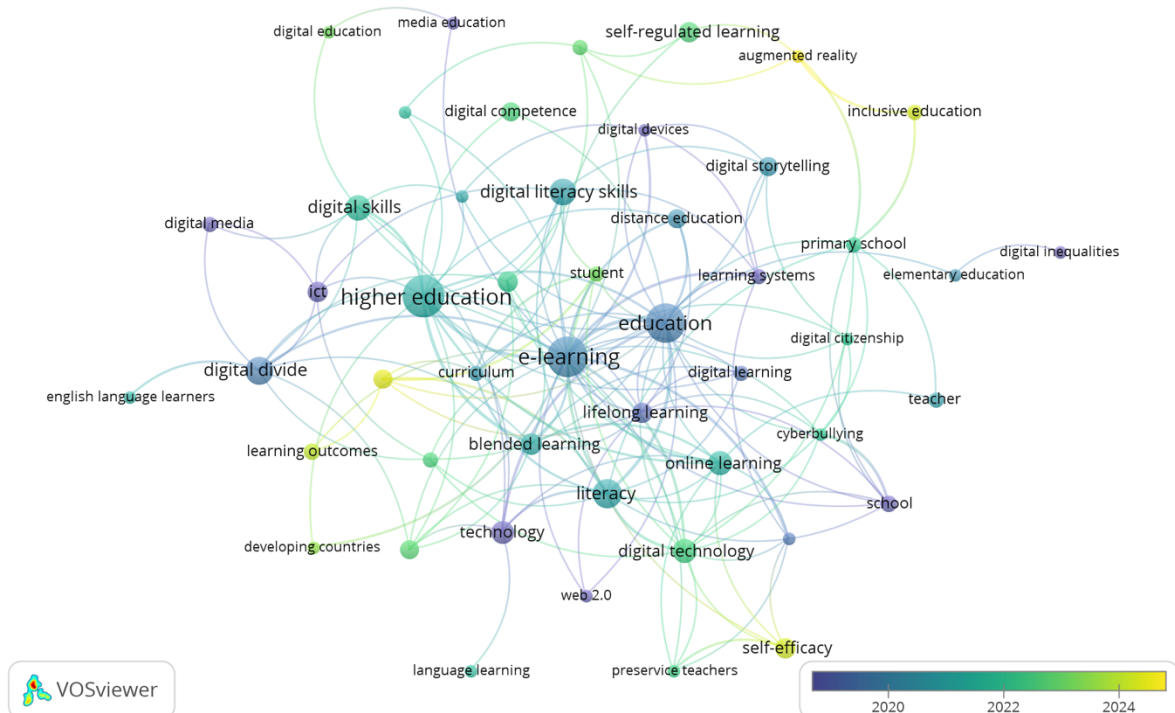

Figure 10. Keyword Novelty in Overlay Visualization Menu

In Figure 10, brightly colored keywords indicate that they are new and rarely used in the literature, signifying a level of novelty and potential for further exploration in the research. Some of the keywords that appear in yellow include "Artificial Intelligence", "Self-efficacy", "Augmented Reality", and "Inclusive Education". The keyword "Artificial Intelligence" shows the connection with digital literacy in the context of using AI to support a more adaptive and personalized learning process, as well as how learners understand and interact with AI-based technology. Meanwhile, "Self-efficacy" refers to an individual's confidence in using digital technology effectively, which is an important element in the development of digital literacy, especially in self-directed learning.

Furthermore, the keyword "Augmented Reality" indicates that this technology is starting to be adopted as an interactive and innovative learning medium, supporting rich learning experiences and enhancing concept understanding through digital visualization. In the context of digital literacy, AR demands new skills in accessing, evaluating and using technology-based information. The keyword "Inclusive Education" expands the digital literacy dimension towards accessibility and equality, emphasizing the importance of inclusive technology for all learners, including those with special needs. These four keywords represent a new direction in digital literacy in education research, combining technological innovation, the psychology of learning, and the principles of inclusivity in the world of digital education.

The emergence of keywords such as "Artificial Intelligence", "Self-efficacy", "Augmented Reality", and "Inclusive Education" reflects the multidimensional integration in digital literacy that is in line with social constructivism theory and motivational theories such as self-determination theory.

These themes support the direction of digital education transformation initiated in various national and global initiatives, such as the Merdeka Curriculum in Indonesia which emphasizes technology-based learning and independent learning, as well as the UNESCO agenda regarding inclusive education and the use of technology for equal access. The existence of these keywords shows that digital literacy is no longer understood purely technically, but includes affective, pedagogical, and social aspects that are closely related to the readiness of individuals and institutions in facing the increasingly complex digital learning ecosystem.

4. Conclusion

Based on a bibliometric analysis of 389 documents in the Scopus database (2005–mid-2025), it was found that the publication trend has increased significantly since 2013, with a peak occurring in 2023. Yogyakarta State University emerged as the most productive affiliate, while Indonesia became the country with the largest number of publications (n=54), although the level of international collaboration is still limited (12.85%). Authors from the United States and Indonesia dominated the article contributions, while the most productive journal was Education and Information Technologies. The most cited documents focused on informal learning, the digital generation, and digital literacy in non-formal contexts. Digital literacy in education has undergone conceptual deepening and diversification of approaches. Eight keyword clusters were identified, with new themes such as "Artificial Intelligence", "Self-efficacy", "Augmented Reality", and "Inclusive Education" indicating the direction of future research developments. These findings indicate that digital literacy encompasses technical competence, affective, pedagogical, and social aspects. However, this

study has several limitations, namely only using data from the Scopus database, and the data used only covers up to mid-2025. For further research, it is recommended that the focus be directed at exploring more deeply the relationship between digital literacy and specific educational contexts, such as vocational education, out-of-school education, or hybrid learning. In addition, aspects such as teacher competence in AI integration, obstacles in implementing inclusive digital-based learning, and the development of digital literacy indicators based on local contexts are still gaps that have not been widely explored.

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