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Research Trends on Digital Literacy in Quality Education: Bibliometric Analysis Form 2000 to 2024

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Abstract

Digital Literacy Although many researchers discuss digital literacy, the contribution of digital literacy research to the quality of education is often fragmented, with diverse and unsystematic topics, approaches, and geographical areas. Therefore, this study aims to analyze global research patterns, trends, and focuses over time, thereby providing a foundation for more effective educational development policies and practices. The research method uses bibliometric analysis. The database used is Dimension.ai with the keywords "digital literacy" AND "quality education" in the period 2000-2024. This search results produced 19,498 publications and a total of 5,783 publications were analyzed. The results of the study show that the trend of digital literacy research in the field of quality education has increased every year. The results of this study in the field of Sustainable Development Goals (SDGs), the most publications are in the field of education with 4,159 publications. Meanwhile, the journal that published the most articles was the Journal of Education and Information Technology. The author with the most publications is Lukasz Tomczyk with 11 publications. The conclusion is that emerging themes in this field are digital literacy levels, digital literacy scales, variables, significant differences, equity, governance, and initiatives that demonstrate the research focus on measurement and policy formulation. The author group with the strongest collaboration is C.R. Safrudin Bachtiar, Abadi Moko Dwi, and Akbar Rasnoha Sunara.

Keywords: digital literacy, quality education, SDGs

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INTRODUCTION

Digital literacy includes not only the ability to use information and communication technology (ICT), but also critical thinking skills in accessing, analyzing, and utilizing information ethically and effectively (Bravo et al., 2021). In the era of globalization and rapid digital transformation, digital literacy has become a key element in improving the quality of education (Akinradewo et al., 2024; Avdeeva & Tarasova, 2023). Along with technological developments, the focus on digital literacy is increasingly receiving attention in the global agenda, including in the *Sustainable Development Goals (SDGs),* or the Sustainable Development Goals which are a set of global goals adopted by all member states of the United Nations (UN) in 2015 as part of the 2030 agenda for Sustainable

Development (Sparviero & Ragnedda, 2021). The SDGs are a continuation of the Millennium Development Goals (MDGs) that were in effect from 2000 to 2015, but with a broader and more inclusive scope, especially in the fourth goal, which is to provide inclusive and equitable quality education and encourage lifelong learning opportunities for all(Clark et al., 2022).

Research related to digital literacy in the context of quality education has undergone significant development since the beginning of the 21st century(Gündüzalp, 2021; Hariyati et al., 2024). This trend is driven by the need to integrate technology into the teaching and learning process, reduce the digital divide, and create a learning environment that is adaptive to changing times and has an impact on transformation in the world of education (Aziz et al., 2020). Although digital literacy has become an increasingly discussed topic in the academic literature, a comprehensive understanding of global trends in research in this field is still limited.Research focused on how digital literacy contributes to quality education is often fragmented, with diverse variety of topics, approaches, and geographic regions. The varying definitions of "digital literacy" between studies (technical vs. socio-cultural) lead to inconsistent keyword classifications. studies categorize "critical thinking" as either part of digital literacy or not. In addition, the lack of systematic analysis of research collaborations and regional impacts makes it difficult to identify areas that need further attention. In this regard, bibliometric analysis provides valuable insights into global research patterns, trends, and focuses over time, thus providing a foundation for the development of more effective educational policies and practices.

This article aims to analyze global research trends on digital literacy in quality education from 2000 to 2024 as follows: 1) find out the trends in publications and citations related to digital literacy research in quality education, 2) find out the topic *of digital literacy* in the field of *Sustainable Development Goals* (SDGs), 3) knowing the journals that publish a lot of digital literacy topics, 4) knowing the researchers who have published many articles on the topic of digital literacy, 5) knowing the co-occurrence of words based on the latest keywords, calsters and themes that show novelty in this research. Through this analysis, this article is expected to make a significant contribution in building a holistic understanding of the role of digital literacy in improving the quality of education in the era of globalization and digitalization. The results of this research are also expectedtalstca to be the basis for better decision-making for policymakers, researchers, and education practitioners.

By identifying the development of research topics, collaboration between researchers, and geographical influences, this article is expected to provide a comprehensive overview of how digital literacy has become an integral part of efforts to improve the quality of education in various parts of the world. Definition: Digital literacy is the ability to access, understand, evaluate, use, and create digital content critically, creatively, and responsibly. Coverage Segmentation: The Role of Digital Literacy in Education & SDGs 21st Century Skills: Integrating critical thinking and digital collaboration in the curriculum. Research Gap Unanswered Issues: Local Contextualization: The majority of research is based on North Global countries, with minimal adaptation for rural areas implementation in suburban schools in West Java). These findings are also expected to be a strategic reference

for researchers, policymakers, and education practitioners in designing programs that are relevant to the challenges of the digital age.

METHODS

This study uses bibliometric visualization methods and bibliometric analysis. As a quantitative method, bibliometric analysis uses an evaluative as well as a descriptive approach to represent research trends and characteristics of a series of publications. This bibliometric analysis is used to check the progress of research and publications, in order to answer research problems. A total of 5783 articles were in accordance with the keywords and criteria given. The researchers used the Dimensions database to search for data sources related to "Digital Literacy." The process of refining the collected data involves several steps. Identification is done first, followed by screening, eligibility, and inclusion(Tugwell & Tovey, 2021). Figure 1 illustrates the data collection procedure.

Data Analysis : Meta-Analysis (If quantitative): Calculate the effect size of the impact of digital literacy training on learning outcomes. : Narrative Synthesis (If qualitative): Compare findings across countries/educational contexts.

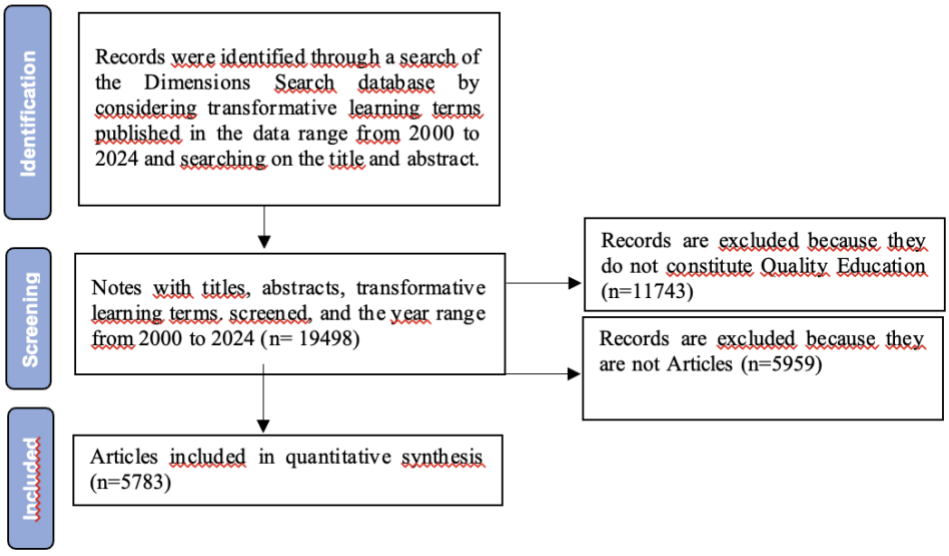

Figure 1. The researchers used the Dimensions database to collect data

The identification process is the first phase in the data collection process, as seen in Figure 1. The researchers used the Dimensions database to collect data. The researcher typed the search keyword "Digital Literacy" for the title and abstract. The search with this keyword was limited by the year of publication, which was from 2000 to 2024. A total of 19,498 publications were obtained as a result of this identification. Next, a screening procedure is carried out based on categories. The research category in the field of SDG-4 Quality Education, produced 7755 publications, which means that 11,743 of them are not publications in the SDG-4 Quality Education category. The next screening is the type of publication in the

form of an article. From this screening, 5783 articles and 5959 non-articles were obtained. Researchers do not specialize in publications in a specific language. So only 5783 articles meet the criteria for further research.

The next research is publication trends including trends in the number of articles, citation trends, and author trends related to digital literacy. The research was conducted by descriptive analysis taken from the Dimensions database using bibliometric analysis. Trends are displayed in the form of a graph using Microsoft excel software.

Research on network, overlay and density related to digital literacy, was carried out with the help of the VOSviewer application by analyzing events accompanied by keywords. The researcher sets a threshold to display the focus of the research. That is, the researcher determines a minimum of 2 publications that use these keywords at the same time**.**

RESULTS & DISCUSSION

1. Number of publications per year

Searches from 2000 to 2024 yielded 19498. publication of scientific articles. Furthermore, there are many digital literacy publications. in the field of Quality Education per year is presented in Figure 2.

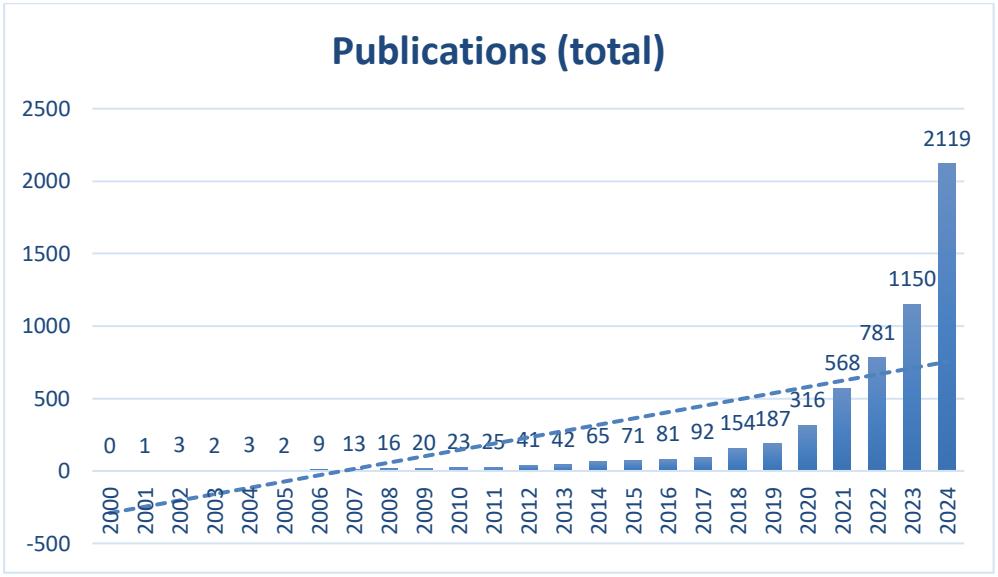

Figure 2. Number of publications on the topic of digital literacy in the field of Quality Education per year

The trend of publications on digital literacy from 2000 to 2024 shows a significant increase, reflecting the growing global attention to the importance of digital literacy in various aspects of life, especially in education. Digital literacy plays an important role in achieving Sustainable Development Goal 4 (SDG 4) on quality education (Shelyugina et al., 2022; Shipe, 2024). With the increasing number of publications that link digital literacy to quality education, it can be seen

that digital literacy is considered the key to improving access and quality of education in the digital era(Afrina et al., 2024).

Bibliometric analysis shows that the number of publications related to digital literacy has increased consistently since the early 2000s. In particular, between 2015 and 2024, there has been a significant growth in the number of publications discussing digital literacy in the context of education. The peak will occur in 2024 with 2119 publications. From 2000 to 2024, there has been a significant increase in the number of publications on digital literacy, especially in the context of education. This trend reflects global awareness of the importance of digital literacy in supporting sustainable learning and development. The significant increase in the number of digital literacy publications between 2022 and 2024 can be attributed to several main factors, including due to the impact of the COVID-19 Pandemic, where the COVID-19 Pandemic has accelerated the adoption of digital technology in various aspects of life, especially in the education sector (M. Li & Yu, 2022)

The trend line on the digital literacy publication graph shows an exponential growth pattern, especially after 2020. This sharp increase reflects the academic response to the urgent need for digital literacy amid the global shift towards digitalization, particularly in the education sector (Gorina et al., 2023). This surge also shows that digital literacy is becoming an increasingly important and relevant research topic in the context of social and technological change (List, 2019). Based on available data, the number of publications related to digital literacy began to exceed 100 in around 2017. This increase is in line with the increasing attention to the integration of technology in education and the need for digital skills in the information age.

2. Numerous citations

The number of citations for digital literacy topics in the field of quality education from 2000 to 2024 is 39850 Furthermore, the number of citations per year is presented in Figure 3.

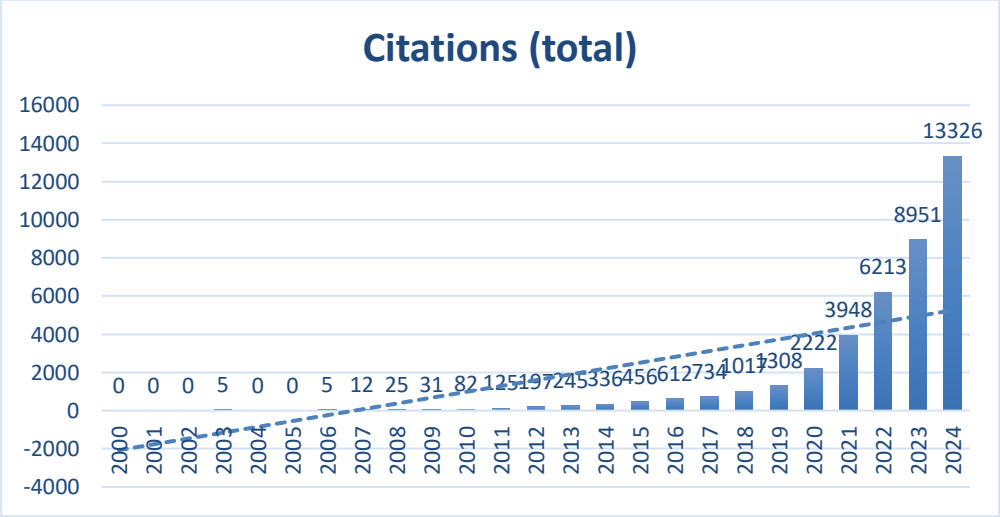

Figure 3. Number of citations on digital literacy topics in the number of citations per year

In Development the number of citations from 2000 to 2024 showed a gradual increase until 2020, followed by a significant spike thereafter. This reflects the increasing relevance of digital literacy in global research, especially during the COVID-19 pandemic(Su, 2023). The most significant spike in citations occurred in the period 2020 to 2023, in line with the increasing academic focus on digital literacy in the context of digital transformation accelerated by the pandemic. The highest number of citations was recorded in 2024, peaking at 13326 citations, which shows the high level of attention and impact of research conducted in previous years. The difference in citation growth patterns is evident before and after 2020. Prior to 2020, citation growth was slow and stable. After 2020, growth has become much faster and exponential due to the increasing global research collaboration and the relevance of digital literacy in everyday life.

During 2000–2006, citations in this field were still low because digital literacy was not the main focus of research. Publications in this period were still very few, and the topic has not received widespread attention from the academic community. This pattern reflects the evolution of digital literacy as a field of research that is now becoming very relevant in the era of global digitalization. The growth pattern of citations follows an exponential pattern, especially after 2020. The graph shows that the increase in the number of citations is happening at an increasingly rapid rate, reflecting the increasing attention to digital literacy as a research area.

The trendline reflects the actual growth of citations quite well, especially for the period after 2010. However, a significant spike after 2020 may lead to some deviation from the trend lines designed to encapsulate the general pattern. The correlation between the number of publications and the number of citations appears strong, as a spike in the number of publications is often followed by an increase in the number of citations. More publications increase the likelihood of citations, although other factors such as the quality of the research and the relevance of the topic also play an important role. The sharp increase in the number of citations from 2021 to 2024 can be attributed to the increasing global attention to digital literacy during the COVID-19 pandemic, more intensive international research collaborations, and the relevance of digital literacy in the transformation of education and daily life.

The number of citations for the first time exceeded 2,000 in 2020. The reasons include a surge in publications on digital literacy during the pandemic, the relevance of topics in supporting online learning, and increasing global interest in digital transformation. The early years (2000–2005) had no citations due to several key factors. First, digital literacy was not yet a significant research topic at the time, so the number of related publications was very limited. Additionally, the relevance of this topic is still low among academics, and many have not yet seen it as an important issue to research. Limited access to international journals and scientific publications is also an obstacle, because technology and digital platforms for research dissemination have not developed as rapidly as they do now. In addition, the research that existed at that time took time to be known and cited by the academic community, so citations only began to increase over time as the topic gained more attention. The total number of citations in 2015 was relatively small compared to subsequent years, reflecting the early growth of digital literacy as a

field of research that has not received widespread attention. The trend line on the chart shows an exponential growth pattern in the number of citations, with a significant increase after 2020. This reflects the increasing number of studies cited as the topic of digital literacy becomes more relevant. Not completely. Although the growth of publications increases the chances of citations, the number of citations is also influenced by other factors, such as the relevance of the topic, the quality of the research, and the contribution of research to the development of science.

High-quality publications are more likely to receive citations because they are considered relevant, innovative, and trustworthy. Factors such as publication in reputable journals, strong methodologies, and significant contributions to a particular field can increase the number of citations. An increase in the number of citations increases the academic influence, reputation, and visibility of the institution or researcher. High citations indicate that such research is considered important by the scientific community, which can open up opportunities for collaboration, funding, and rewards. The early years did not have citations because digital literacy was not yet the main topic of research. The limited number of publications, the lack of relevance of the topic at the time, and the lack of global academic networks meant that research in this period was not widely accessed or referenced.

The increase in the number of citations is influenced by various key factors. Research that discusses current issues is more likely to be cited because of its relevance to the needs of the times. The quality of the research, including its robust methodology, valid analysis, and innovative contributions, is attracting more attention from the academic community. International collaboration also plays an important role, as joint research has a wider reach. Publications in reputable journals with a high impact factor increase the likelihood of citation due to their credibility. Research that provides a social impact or practical solution is often referred to for its tangible benefits. In addition, citations take time to develop after publication, so their effects are often seen gradually. High citations have a positive impact on the reputation of researchers and institutions, increasing academic influence, global visibility, collaboration opportunities, funding, and recognition in academic careers.

3. Sustainable Development Goals (SDGs)

Based on the field of research, publications on the topic of ***digital literacy*** in the field of *Sustainable Development Goals* (SDGs) can be grouped. Furthermore, the number of publications based on the field of Sustainable Development Goals (39 largest) is presented in Figure 3.

The graph above shows the distribution of the number of publications based on the Fields of Research (FoR) classified according to the ANZSRC 2020. Through the use of horizontal bar charts, a significant difference in the number of publications in various disciplines can be seen. This data provides a clear picture of research concentrations in a particular field, with the field of education seen dominating.

The field of Education (number 39) ranks at the top with a very significant number of publications, almost reaching 4159 This figure shows a clear dominance when compared to other fields (Bacalja et al., 2022; Le et al., 2022; Smith & Storrs,

2023). This phenomenon can reflect the high interest of academics and researchers in various educational issues, ranging from learning theory, educational technology, education policy, to innovative approaches in teaching and learning practices. In addition, the transformation of education globally, especially during and after the pandemic, is likely to play a role in increasing the number of publications in this field.

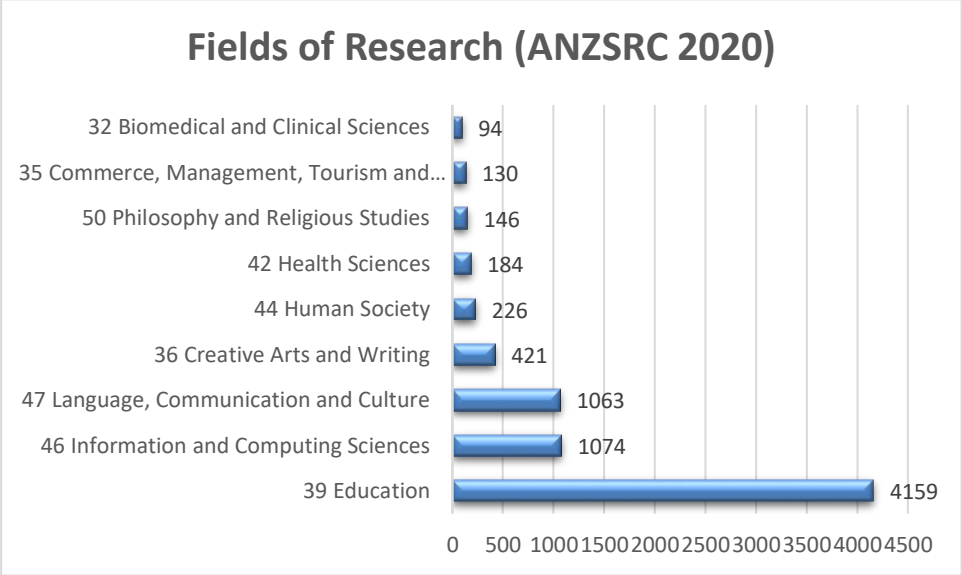

Figure 4. The number of publications on the topic of digital literacy in quality education from the field of Sustainable Development Goals

Below it, there are two fields that record a significant number of publications compared to other fields, namely Information and Computing Sciences (number 46) and Language, Communication and Culture (number 47), which each has more than 1000 publications, one of the publications from both fields is J. Li et al. (2024)) and Aranda et al. (2023). These two fields are closely related to the advancement of information technology and the role of communication in contemporary society. Information and computer science contribute a lot to the fields of education and social life, while the study of language and culture focuses on aspects of literacy, media, and the formation of social identity.

Other fields, such as Creative Arts and Writing (number 36), Human Society (number 44), Health Sciences (number 42), Philosophy and Religious Studies (number 50), as well as Commerce, Management, Tourism and Services (number 35) and Biomedical and Clinical Sciences (number 32), show relatively lower number of publications, with the number of publications being below 500. Although not as large as the fields of education or technology, the contributions of these fields remain significant in the overall research landscape. For example, the fields of health and biomedical sciences remain highly relevant, especially in the context of pandemics, while philosophy and religious studies make a contribution to critical and reflective thinking to human life.

Based on the overall data presented, it can be concluded that scientific research and publications are currently very focused on the field of education, which is significantly driven by the advancement of information and

communication technology. This graph also reflects policy directions and research interests that may be influenced by social needs, technological advances, and paradigm shifts in education and communication. This information provides very useful insights for designing future research strategies as well as understanding global trends in the academic realm (Abad-Segura et al., 2020; Liu et al., 2024).

4. Journal

Based on journals, publications on the topic of digital literacy in quality education can be grouped. Furthermore, the number of publications based on the top 10 is presented in Figure 5

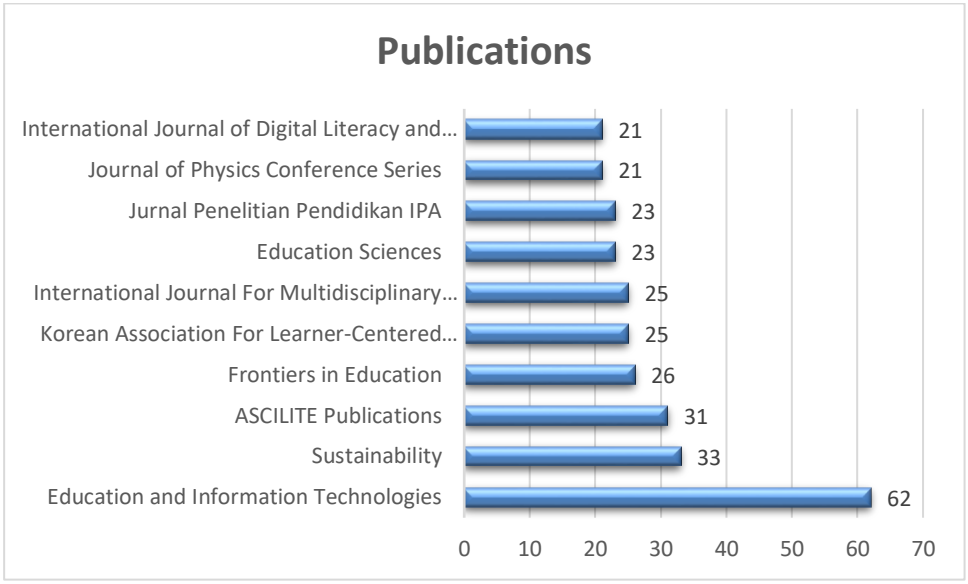

Figure 5. The number of publications on the topic of digital literacy in quality education is reviewed from the journal

Figure 5 graph shows data on the number of publications distributed in a number of scientific journals with the theme "Publications". Through the horizontal bar graph, there is a quite striking variation in the number of publications in each journal. This visualization clearly reflects the trend and frequency of publications in various academic journals that focus on the fields of education, technology, and multidisciplinary studies.

The journal with the highest number of publications is *Education and Information Technologies*, with a total of about 62 publications. The dominance of the journal indicates that the issue of technology integration in the field of education is one of the main focuses in academic research. This condition reflects the global trend in education studies that increasingly emphasizes the use of digital technology, both as a learning medium and as an object of scientific study.

Furthermore, the journal *Sustainability* and *ASCILITE Publications* ranked second and third with the number of publications of around 35 and 30 articles, respectively. The two journals have a wide range of topics, especially related to continuing education and technological innovation in the learning process. Their prominent position in the number of publications shows that the issue of

sustainability and the integration of information technology in education is a very dynamic area and receives great attention in the realm of scientific research and publications.

On the other hand, there are a number of journals that have a relatively balanced number of publications, ranging from 20 to 22 articles. Some of them include the International Journal of Digital Literacy and Digital Competence, the Journal of Physics Conference Series, the Journal of Science Education Research, Education Sciences, the International Journal for Multidisciplinary Research, the Korean Association for Learner-Centered Curriculum and Instruction, and Frontiers in Education. Although the publication contributions of these journals are not as large as those of the main journals, their existence remains significant as it reflects the diversity of themes raised in academic research. The focus of studies in these journals includes the fields of science education, digital literacy and competence, curriculum development, and student-oriented learning approaches.

Based on the overall data presented, it can be concluded that the current direction of publication tends to focus on technology integration and the application of interdisciplinary approaches in the realm of education. The visualization of the graph also illustrates the preference of researchers in selecting internationally reputable journals with broad coverage, in order to expand the reach of the audience while increasing the significance of the scientific impact of their research results. Therefore, this graph not only presents the quantitative distribution of publications, but also provides a strategic understanding of the development of the main directions and focuses in cutting-edge research related to the fields of education and technology.

5. Researchers

Based on the researcher, publications can be grouped. Furthermore, the number of publications based on the 10 largest researchers is presented in Figure 6.

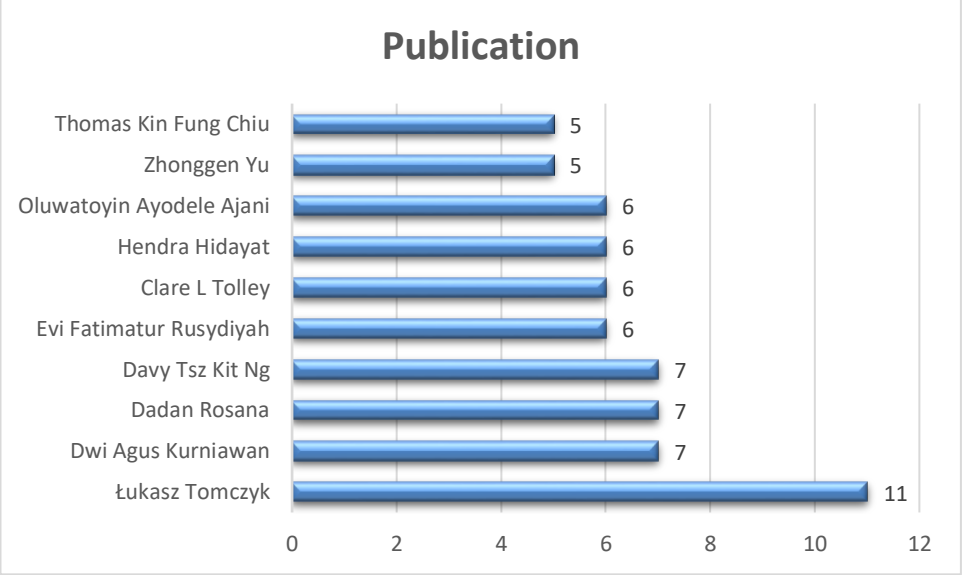

Figure 6. The number of publications on the topic of digital literacy in quality education reviewed by the researcher

Based on the graph of the number of publications related to the theme of digital literacy above, it can be seen that Lukasz Tomczyk is the most prolific researcher with 11 publications, here are some of his publications Tomczyk et al. (2020, 2023, 2024)much higher than other researchers. Three researchers, namely Astalini et al., (2024); Ng, (2022); Perdana et al. (2019) Both have 7 publications, showing quite consistent contributions. Meanwhile, Evi Fatimaturrusydiyah, Clare L Tolley, Hendra Hidayat, and Oluwatoyin Ayodele Ajani each have 6 publications, followed by Thomas Kin Fung Chiu and Zhonggen Yu with 5 publications. In general, these data show that the topic of digital literacy has attracted the attention of various researchers from different backgrounds, with a tendency for collaboration or stable interest among certain groups of researchers.

6. Network visualization for co-occurrence

VOSviewer provides a network visualization map. Furthermore, the network visualization for the co-occurrence of digital literacy of this term is presented in Figure 7.

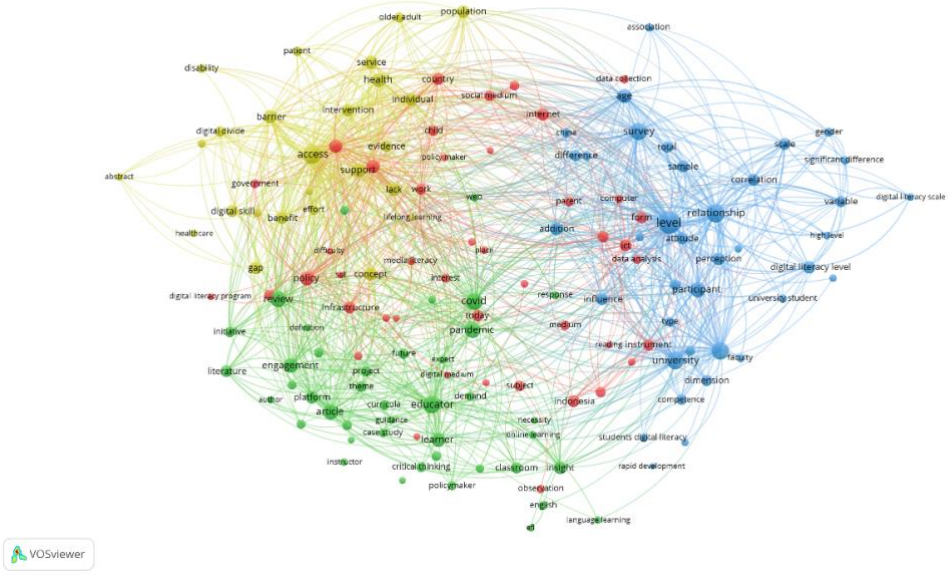

Figure 7. Network visualization on the topic of digital literacy

Based on the network visualization using the keyword 'digital literacy' generated through VOSviewer, there is a division into several main clusters that are differentiated based on color. The green cluster depicts a focus on education, learning, and digital literacy issues, with dominant keywords such as *learner*, *educator*, *classroom*, *platform*, and *engagement*. This cluster reflects a study that emphasizes the development of digital literacy in the context of education as well as relevant pedagogical approaches.

The blue cluster emphasizes research based on surveys and correlational analysis, with keywords including *level*, *university*, *faculty*, *survey*, and *correlation*. This cluster reflects a quantitative study that seeks to map the level of digital literacy based on demographic attributes, particularly in the student population.

On the other hand, the yellow cluster focuses on access issues, policies, and structural barriers in the equitable distribution of digital literacy, which are shown through keywords such as *access*, *support*, *policy*, *digital divide*, and *barrier*. These clusters are often related to the context of public services, health, and government policies.

Meanwhile, the red cluster displays contemporary and contextual issues, with keywords such as *covid*, *online learning*, *internet*, *social medium*, and *Indonesia*. This reflects the scientific response to the rapid changes in digital literacy during the COVID-19 pandemic, as well as the influence of social media and local dynamics in the process.

In this network visualization, the size of the node or circle reflects the frequency of the keyword's occurrence in the literature being analyzed. The larger the size of a node, the more often the word appears in the documents under review. Keywords such as *access*, *support*, *university*, *covid*, and *learner* stand out because they have large node sizes, which indicates that these themes are the main focus in research on digital literacy.

Furthermore, the relationship between keywords is indicated by a connecting line or *edge* which represents the relationship or coexistence between two terms in one article. The density and thickness of the lines indicate the frequency of connectivity between concepts; For example, the words *access* and *support* seem to have a very close relationship because they often appear together in various publications.

The number of connecting lines between clusters also indicates that although there are different focus of studies in each cluster, the topics are still interrelated with each other, creating an integrative knowledge network in digital literacy studies.

7. Overlay visualization for co-occurrence

Likewise, VOSviewer provides a map overlay visualization. Next, the visualization overlay for the co-occurrence of this term digital literacy is presented in Figure 8.

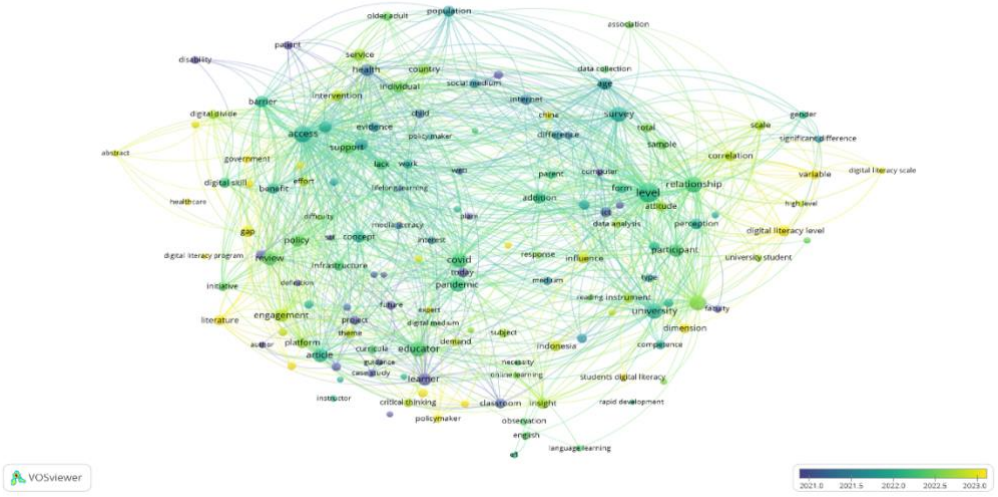

Figure 8. Overlay visualization on digital literacy topics

Based on the overlay visualization produced by VOSviewer, there is a color distribution on the keyword map that shows the temporal trend of research development related to *digital literacy* in the context of SDG-4 Quality Education. The purplish-blue color signifies that the topic dominated publications in the early years (around 2021). Green indicates a transition period (2022), and yellow indicates a relatively new and emerging topic (2023–2024).

The initial topics that became the foundation of the research included *access*, *health*, *support*, *survey*, *internet*, *covid*, *learner*, *critical thinking*, *educator*, and *media literacy*. Most of these keywords are closely related to the context of the COVID-19 pandemic, public health issues, and access to digital learning, which shows that the pandemic has contributed greatly to the surge in attention to digital literacy.

Entering the 2023–2024 period, the emergence of keywords such as *digital literacy level*, *digital literacy scale*, *variable*, *significant difference*, *gap*, *government*, and *initiative* indicates a shift in research focus towards measurement, evaluation, and policy formulation. Keywords such as *gap* and *initiative* also show increasing attention to digital access inequality and intervention efforts that are being designed or implemented. In the context of SDG-4 Quality Education, the relationship between digital literacy and quality education is evident through the emergence of keywords such as *university*, *faculty*, *educator*, *learner*, *classroom*, *online learning*, *curricula*, and *language learning*. This confirms that digital literacy research is still very dominant in the realm of formal education, especially at the higher education level, and supports the goal of improving the quality of technology-based learning.

Structurally, this visualization network also shows the high intensity of multidisciplinary scientific collaboration. Nodes with larger sizes such as *universities*, *surveys*, and *faculty* show terms that appear frequently, which can also represent a central institution or theme in the knowledge network. The strong relationship between terms also reflects cross-field collaboration, especially between the fields of health, education, and public policy, which enriches research approaches on digital literacy issues more comprehensively.

8. Density visualization for co-occurrence

In addition, VOSviewer displays a density visualization map. Furthermore, the density visualization for the co-occurrence of digital literacy of this term is presented in Figure 9.

The author keyword density *visualization* generated by VOSviewer shows the concentration or density of keywords that most often appear in the literature related *to digital literacy* within the framework of SDG-4 Quality Education. Bright yellow areas indicate areas with high keyword frequency, reflecting the main research focus and center of scientific discourse. From the visualization, it can be seen that keywords such as covid, pandemic, access, support, level, relationship, university, learner, and educator are high-density areas, indicating that these topics have been the dominant themes in research over the past two decades, especially during and after the COVID-19 pandemic.

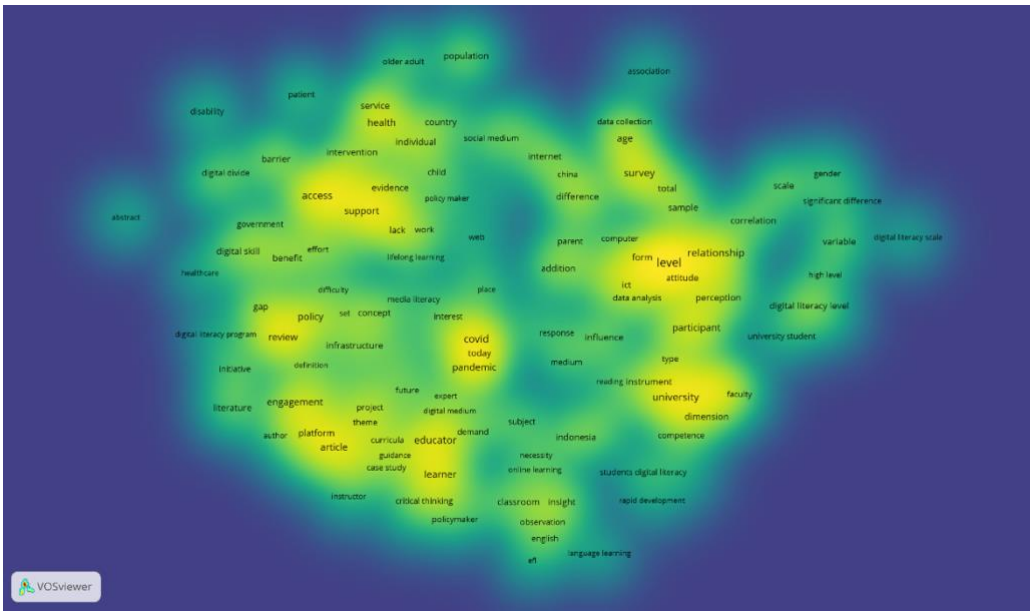

Figure 9. Density visualization on the topic of digital literacy

Topics such as covid, today, and pandemic are at the center with very high density, showing how the pandemic has been a major catalyst in the surge in publications related to digital literacy. Keywords such as access, support, policy, and gap also show high attention to accessibility aspects and policy interventions in the context of digital literacy, especially for groups affected by the digital divide. Meanwhile, keywords related to the educational context such as university, faculty, learner, classroom, and educator also show high density, which confirms that higher education is the main domain where digital literacy research develops, in line with the SDG-4 Quality Education goal to ensure inclusive and quality education.

In addition, several other keywords such as review, article, platform, and engagement indicate a concentration of theoretical discussions and literature reviews that develop within an academic framework. Meanwhile, topics such as digital literacy level, variables, and significant differences, although on the margins, still show significant linkages with new trends that are more quantitative and analytical in research approaches.

Overall, this visualization provides a clear picture that research on digital literacy is greatly influenced by global dynamics (such as the pandemic), the need for distance learning, and the urgency of equitable access to technology in education. This data reinforces the relevance of digital literacy as an important element in achieving SDG-4 Quality Education and opens up space for researchers to explore issues such as the digital divide, policy effectiveness, and future digital learning transformation.

9. Network visualization for co-authorship

In addition, VOSviewer shows network visualization for co-authorship. Furthermore, the network visualization for co-authorship of the author's digital literacy is presented in Figure 10.

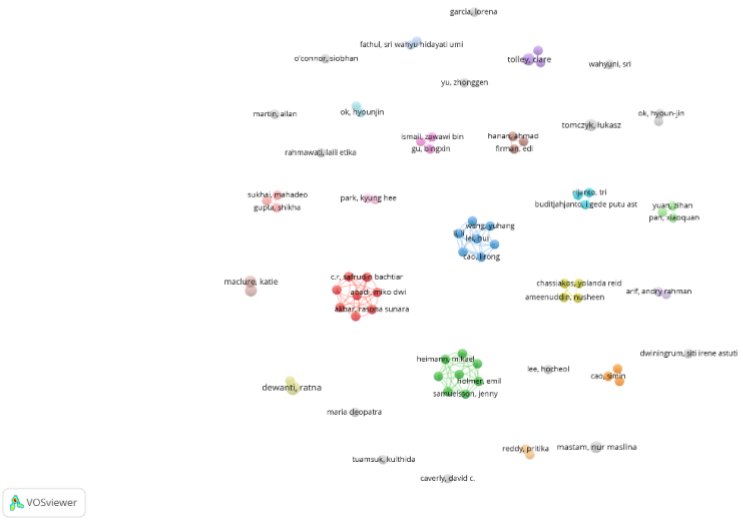

Figure 10. Network visualization for co-authorship on digital literacy topics

Using VOSviewer, visualization of author collaboration networks shows that research on digital literacy in the context of SDG-4 Quality Education published between 2000 and 2024 is dominated by several groups of authors that form strong collaborative clusters. Groups of writers such as C.R. Safrudin Bachtiar, Abadi Moko Dwi, and Akbar Rasnoha Sunara are the most powerful examples of clusters.

In addition, it appears that writers from the East Asian region such as Liu Bui, Li Rong, and Wang Yuhang are actively collaborating on publications related to digital literacy. European authors such as Heimann Mikael, Holmer Emil, and Samuelsson Jenny formed a special cluster that showed a research focus on the primary to secondary education environment in the Nordic countries. On the contrary, writers such as Dewanti Ratna, Maclure Katie, and Mastam Nur Maslina work individually or have not formed strong collaborations. These results show that, although research on digital literacy continues to grow, there is still room for increased cooperation across institutions and countries.

The great contribution of Southeast Asia, especially Indonesia, to the development of digital literacy in the framework of quality education is also shown by the presence of writers such as Tri Rijanto, Buditjahjanto I Gede Putu Ast, and Firman Edi. Overall, the network shows that digital literacy issues are multinational and span a wide range of disciplines. Collaboration between authors is also an important factor in encouraging the achievement of SDG-4 Quality Education goals through academic studies.

CONCLUSION

In this study, the *trend of* digital *literacy research in* quality education has increased every year from 2000-2024. The highest number of citations has increased, namely in 2023-2024. This research shows that digital literacy is an important topic to be researched in the context of quality education. Through

bibliometric analysis, it was found that the global research focus began to shift towards digital literacy measurement and policy formulation with the emergence of new themes such as *digital literacy scale* and *government initiatives*. The findings also identify authors who have been productive in researching this topic as well as collaborations among authors. Cross-border research collaboration is needed to strengthen the integration and continuity of digital literacy studies, especially in supporting quality education and the Sustainable Development Goals (SDGs). Further exploration of emerging themes is recommended to ensure that the research results are more applicable in designing context-based and data-driven education policies. This research has limitations from the data base used and the field studied. It is expected that other researchers will use a wider database such as *Scopus, web of science* etc. and conduct studies in other fields.

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