Exploring the Nexus of Technology, Digital, and Visual Literacy: A Bibliometric Analysis

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Article Info	Abstract
	Through a bibliometric analysis, this study aimed to uncover the connections between technology, digital and visual literacy, and education. By examining the Web of Science database, we were able to gain insight into the scope of the topic and interdisciplinary trends in the literature. Our analysis revealed that journals such as the Nordic Journal of Digital Literacy, Computers & Education, and Education and Information Technologies are important and frequently cited resources in this area. Notable researchers such as Buckingham, D., McGrew, S., and Coiro, J. were identified through our author analysis. Our trend analysis demonstrated the growing importance of digital literacy, technology, and education. Through cluster analysis, we were able to identify relationships and topics between keywords. Our findings suggest that digital literacy education should be prioritized, technology should be more widely utilized, and teachers should be trained to collaborate and share. This study provides helpful guidance for educators and researchers and can inform future studies. Our goal is to encourage the development of effective strategies for technology and digital literacy in education. Further research should focus on improving students' digital skills, increasing the impact of technology in education, and enhancing learning experiences.

Introduction

Although literacy is generally confused with a concept that refers only to the ability to read and write, it includes the capacity to understand, produce and communicate ideas, experiences, information, and meanings. With this definition, literacy is a set of abilities that involve communicating and creating meaning using symbol systems specific to a culture. A group of individuals who can understand, interpret and write texts are said to be literate. In this context, they can use texts effectively, enjoy their form, structure, and function, and examine them critically. They can also observe how texts represent the outside world. Texts can also be expressed verbally or in writing, visually or audibly, or with various other symbolic representations (Hobbs, 2016: 1).

Literacy is a concept related to perceiving and understanding life and attributing meaning to social relations,

together with reading and writing activities. This concept, which was born in Western culture, has started to become widespread. Literacy is a broad educational term that includes not only reading and writing but also mental skills, communication skills, and attitudes. Today, literacy, which is no longer limited to writing symbols, is an important skill that expresses communication using language. Our way of life needs to be re-evaluated in light of developing living conditions, urbanization, and communication technologies. In this respect, one of the attitudes and actions that should be examined is literacy. This concept, which was limited to reading and writing activities, has now permeated almost every area of life with its various forms and manifestations (Aşıcı, 2009).

Literacy is an important factor for nation development, people need to have literacy skills to be successful and actively participate in international events. At the same time, literacy is accepted as a basic requirement for personal development and success (Rintaningrum, 2009). Literacy skill affects one's capacity to integrate socially, organize one's environment, develop a free and autonomous personality, acquire a contemporary perspective, and live in harmony with technology. Therefore, in today's culture, providing people with up-to-date literacy skills is a basic prerequisite for the continuation of social communication and life intertwined with technology (Kurudayıoğlu & Tüzel, 2010).

Due to the rapid growth of information technology, several concepts such as computer literacy, digital literacy, technological literacy, and e-literacy have emerged in recent years (Güneş, 2019). Therefore, new literacies are being added by expanding the definition of literacy every day. Media literacy, information literacy, computer literacy, digital literacy, screen literacy, and technology literacy are all examples of 21st-century literacy. In this context, it is striking that the primary power that transforms literacy is technology (Arslan, 2019). Therefore, contemporary literacy is no longer determined only by the ability to read and write, but also by multiple literacies, including digital, visual, multimodal, and many other literacy (Kedra, 2018).

"Digital Literacy is defined as the awareness, attitude, and ability of individuals to use digital tools and possibilities appropriately to identify, access, manage, integrate, evaluate, analyze and synthesize digital resources, create new knowledge, create media expressions and communicate" (Martin, 2006b). At the same time, digital literacy describes the abilities/skills a person needs to enter, use, comprehend, and contribute to the contemporary digital information economy. In other words, it is the skill set required for a person to become an active member of the world through the modern internet.To be considered digitally literate, a person must understand: how to use modern digital technologies to access information, how to navigate the complex web of the information offered by digital technologies, how to "read", and "understand" messages in digital media, and how to navigate the digital information economy using digital technology. It is also important to know how to contribute (Baron, 2019). Within the framework of these definitions, digital literacy is the capacity to successfully interact with the technological tools and infrastructure that support the twenty-first-century world. At this point, various trends have led digital literacy to be a key facilitator in the field of education. The world is e-penetrating, which is its most important aspect. Today, the majority of social segments and most human activities rely on electronic tools and infrastructure. In terms of academic success, job prospects, and other aspects of life, those who can use e-expectations and feel comfortable doing so gain a great deal of power and benefit/advantage (Martin, 2006a). The degree of digital literacy directly affects how well a person embraces new technology. A

digitally literate person can actively access the information they need to solve problems, analyze this information efficiently for their purposes, and add new information (Onursoy, 2018: 1007). Digital literacy, which is also defined as the ability to successfully use Information Communication Technology (ICT) tools and the internet, refers to the capacity of individuals to position, evaluate, use, share, and create information responsibly and ethically in today's context. Today, digital literacy, which is a very important component of both personal and professional life, is also important for survival and success (Reddy et al., 2022: 83).

The articulation of the concept of "literacy" to the digital concept led to the use of the concept of "digital literacy"; its articulation with technology enabled the use of the concept of "technology literacy" (Yeşilyurt & Vezne, 2023). Technology literacy is knowing what can be done with technology by knowing the potential of technology, knowing how to use technology effectively and competently, and deciding when to use technology according to its type (Davies, 2011). In this context, technological literacy refers to the skills required to understand and address the operation of technologies that are at the center of many demands of the 21st century (Hasse, 2017). Technological literacy is an area where the concept of multi-literacy gains importance in parallel with the development of the general literacy movement. Unlike the traditional one-dimensional approach, technological literacy includes a wide range of cognitive skills and encompasses contemporary developments. The importance of technology literacy is increasing with today's technological developments and it is of great importance for students to gain proficiency in this field in terms of a social and democratic approach (Williams, 2009). Technology literacy refers not only to the ability to use computers and machines but also to the ability to understand the factors involved in the creation and development of technologies and the effects of technology on society, individuals, and the environment. Technological literacy is also about the ability to use technological tools to understand how technology can help us solve problems individually or as a society, to understand the essence of the process of designing tools and changing nature, and to gain a realistic view of limits and possibilities (Bugliarello, 2000). Literacy has been expanded to include both reading and writing thanks to Gutenberg. The ease of producing and sharing photos has become possible thanks to the portable camera. For this reason, educators have introduced the concept of visual literacy by emphasizing the importance of understanding how to look at images and how they convey meaning (Alagu & Thanuskodi, 2019). It is a fact that many types of literacy have emerged today. By the principle of preparing the individual for life, which is one of the main functions of education, these new types of literacy should be known, and learned and skills for these types should be developed. One of the literacies emerging in this framework is visual literacy (Tüzel, 2010). visual literacy; It is an interdisciplinary concept that includes fields such as graphic design, architecture, engineering, industrial product design, and instructional technology. The capacity to understand and produce visual communication is what this concept defines. Visual literacy is very important to raise the standard of the teaching-learning process and increase its effectiveness. However, studies show that the use of visual literacy in teaching and learning is insufficient. It is an undeniable fact that both teachers and students need to improve their visual teaching skills (Alpan Bangir, 2008). Although university education is still heavily based on texts, it has been seen that the importance of visual education has been more accepted in recent years. visual literacy; media literacy is used as one of the skills of digital literacy or multimodal literacy. In the context of visual communication with contemporary digital tools, it should be known that visual literacy deserves individual recognition and more attention (Kedra, 2018).

The digitization of every aspect of public life is also directly related to the development phase of the society we are currently in (Barakina et al. 2021). The ability to both produce and understand certain types of information, in this case, computer-generated visual content, is called digital visual literacy, a concept that has evolved in this context. Digital visual literacy is now essential for many tasks in daily life and work, such as critically analyzing newspaper photos or the evening news on television, using a digital camera, creating websites, creating presentations, and modeling and visualizing data in almost all sciences. Digital visual literacy is, of course, a core skill for all visual-focused disciplines. However, the key ideas of digital visual literacy should be identified and incorporated into the current curriculum (Spalter & Van Dam, 2008). It has become a necessity to carry out scientific research and offer solutions to the problems at the point of solving these problems. In this context, the literature needs to conduct important content and analyses on a wide variety of subjects to follow the development process of technology and digital literacy over time. Not only for digital literacy, but also for technology literacy and visual literacy; research is very important in this respect, as it makes it possible to focus on gaps in the field, identify research trends, and monitor its progress over time. Such bibliometric analyzes also allow for a pluralistic experience as opposed to a subjective one. This framework for future research is expected to benefit from this study, which evaluates the numerical, contextual, and impact trends of technological and digital literacy research, as a resource. In this context, this study aims to emphasize the importance of common basic skills between technology, digital and visual literacy. These three areas of literacy are necessary for individuals to communicate effectively in the contemporary world, access information, and act consciously in digital environments.

Technology literacy in the literature; is defined as "the ability of individuals to understand, use and manage technological tools". Digital literacy is defined as "the skills to interact with, evaluate and share information with digital content" and visual literacy is defined as "capacities/skills to understand, interpret and critically evaluate visual media". This study, which aims to analyze the studies published in the Web of Science database on these fields, emphasizes that these three literacy areas should be considered together and aims to evaluate the research in these fields together. This provides an important perspective for individuals to be successful in the digital world and to act effectively in complex information environments. The results of the research aim to create a guiding resource for educators, researchers, and policymakers by revealing the development trends in these fields.

This study aims to explore the relations and developments between technology, digital and visual literacy through the bibliometric analysis of the articles published in the Web of Science database and to present a different perspective to the research in this field. For this purpose, answers to the following research questions are sought:

1. What are the disciplines in which research in the field of technology, digital and visual literacy are concentrated?
2. Which are the journals, conferences, and publications where researches in the field of technology, digital and visual literacy take place frequently?
3. Who are the most influential authors in the field of technology, digital and visual literacy?
4. What are the main topics that researchers in the field of technology, digital and visual literacy focus on?
5. What themes emerge in the co-occurrence analysis of research in technology, digital and visual literacy?

Method

Analysis Tools

The present study utilized the bibliometric mapping approach to analyze papers focusing on technology, digital and visual literacy across various dimensions. Bibliometric mapping refers to the visual representation of connections between disciplines, fields, individual publications, or authors (Small, 1999). By quantifying and analyzing specific aspects of research within a particular field, bibliometric studies offer insights into emerging trends (Kasemodel et al., 2016). This type of analysis allows for tracking studies, researchers, institutions, and the flow of scientific knowledge related to the chosen research topic (Martí-Parreño et al., 2016). Through quantitative analysis and statistical methods, researchers can identify publication patterns within a specific literature domain. Bibliometric evaluation methods are employed to assess the impact of individual authors or to explore relationships between multiple authors or works (Thanuskodi, 2010). The authorized analysis technique encompasses three important processes: research mapping, quantitative analysis, and trend and pattern analysis.

Data Collection

To obtain the literature covering research in technology, digital and visual literacy, a search was conducted on the Web of Science database using relevant keywords. The keywords "technology literacy", "digital literacy" and "visual literacy" were chosen to be used in the query. While these represent different dimensions of the technology literacy field, they are also interrelated. Therefore, by using these keywords together, different dimensions of technology literacy research and the relationships between these dimensions can be emphasized. Figure 1 presents the PRISMA flow diagram depicting the stages of determining the articles used in the analysis process. Queries were conducted using keywords related to the topic to access relevant articles.
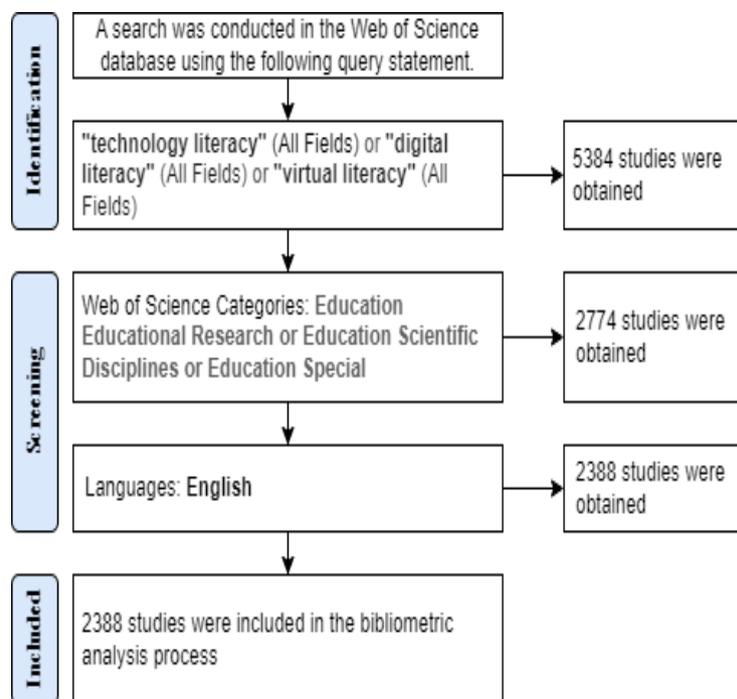
Figure 1. PRISMA Flowchart of the Analysis Process

After the disciplinary analysis of the 5384 publications obtained, the Web of Science category (Education Educational Research, Education Scientific Disciplines, Education Special) filter was applied to reach only the studies related to education. Then, in order to determine the trends with content analysis, a language filter was applied to reach the studies made only in English. This aimed to eliminate studies unrelated to the topic. Table 1 contains descriptive data from the studies obtained.

Table 1 shows that 2388 publications derived from 756 different sources began in 1983 and have continued till the present. Despite an annual rise of 12.52% in the number of publications, the average citation rate per document is 9.13. The number of documents with a single author in these investigations, in which 4718 writers participated, is 777. There are 2.38 co-authors per document.

Table 1. Descriptive Data of Obtained Studies

Description	Results
Timespan	1983:2023
Sources (Journals, Books, etc.)	756
Documents	2388
Annual Growth Rate %	12.52
Average citations per doc	9.13
Authors	4718
Single-authored docs	777
Co-Authors per Doc	2.38

Figure 2 depicts the distribution of the number of studies by year.
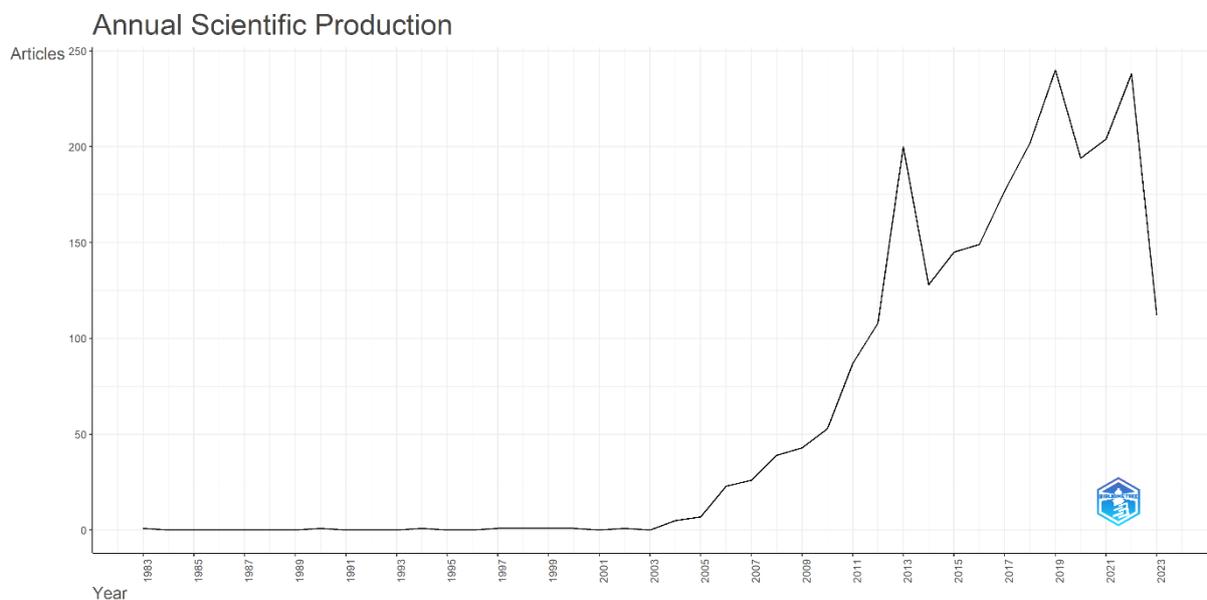
Figure 2. Yearly Distribution of the Number of Studies

When the distribution of the number of publications is analyzed by years, it is seen that the publications on

"technology literacy", "digital literacy" and "visual literacy" have increased over time after 2005. The highest number of publications was recorded in 2013, peaking at 247 articles. The years 2019 and 2021 also represent a busy period with over 200 publications. Although the number of publications started to decrease after 2013, it is seen that over 200 publications are still recorded in 2020 and 2022.

Data Analysis

To determine the general discipline in the first of the research questions, all 5388 publications were included in the analysis. However, the answers to the following questions were tried to be determined through the analyzes made on 2388 publications by filtering the categories related to the English language and education. The following steps were followed in the analysis process of the collected articles:

- Bibliometric analysis: In which disciplines the articles are concentrated, the distribution of journals, conferences, or publications in which they are published, and the authors who work are examined.
- Citation analysis: By examining the citations in the articles, the number of citations of the journals and authors, the number of common citations, and the number of bibliographic matches were examined. The determination of the most cited sources and authors shows the important sources that stand out in the field of technology, digital and visual literacy.
- Trend analysis: Trend analysis is performed to determine the trends in technology, digital, and visual literacy research over time. The frequency of use of the keywords of the publications and the evaluation of how the trends change over time are carried out.

Results

Intensively Researched Fields in Technology, Digital, and Visual Literacy

The keywords "technology literacy," "digital literacy," and "visual literacy" were employed in a search query conducted on the Web of Science database to identify the academic domains focusing on research related to the subject. A comprehensive analysis was performed on all 5384 collected studies without any specific filters. The investigation included an examination of Web of Science Categories, and Table 2 displays the top 10 categories with the most publications. The data in Table 2 highlights that the field of Education and Educational Research exhibits the highest concentration of studies, followed by the categories of Information Science Library Science, and Communication. It is noteworthy that other disciplines are represented to a lesser extent.

Table 2. Areas of Focus of Papers

Web of Science Categories	Record Count	% of 5.384
Education Educational Research	2609	48.458
Information Science Library Science	519	9.640
Communication	430	7.987
Computer Science Interdisciplinary Applications	306	5.684
Computer Science Information Systems	262	4.866

Web of Science Categories	Record Count	% of 5.384
Education Scientific Disciplines	223	4.142
Computer Science Theory Methods	197	3.659
Social Sciences Interdisciplinary	179	3.325
Health Care Sciences Services	166	3.083
Linguistics	161	2.990

Journals, Conferences, and Publications Where Technology, Digital, and Visual Literacy Research Are Frequently Featured

Techniques such as bibliographic matching, citation analysis, and co-citation analysis are used to study the structures and relationships of knowledge networks in scientific communities. These analyses help us understand the diffusion processes of scientific knowledge by revealing important studies, interdisciplinary connections, and effective research networks. Total citation, co-citation, and bibliographic matching results of journals, conferences, and other publications publishing in the field of technology, digital and visual literacy are given in Table 3.

Table 3. Comparison of Sources in Citation, Co-Citation, and Bibliographic Coupling

	Citation Analysis				Co-Citation			Bibliographic Coupling	
	Source	P	TC		Sources	TC		Sources	LS
1	Nordic Journal of Digital Literacy	281	2775	1	Computers & Education	2000	1	Nordic Journal of Digital Literacy	27334
2	Computers & Education	36	1874	2	Computers in Human Behavior	636	2	Education and Information Technologies	10091
3	Education And Information Technologies	53	910	3	British Journal of Educational Technology	551	3	Computers & Education	9967
4	Journal Of Research on Technology in Education	15	652	4	Nordic Journal of Digital Literacy	486	4	Digital Literacy: Concepts, Methodologies, Tools, And Applications, Vol	5695
5	Comunicar	20	649	5	Journal of Computer Assisted Learning	457	5	Literacy	3939
6	Learning Media and Technology	22	639	6	Journal of Adolescent and Adult Literacy	434	6	Learning Media and Technology	3595
7	Journal Of Computer	7	573	7	Thesis	424	7	Journal Of Literacy Research	3549

	Citation Analysis				Co-Citation				Bibliographic Coupling	
	Assisted Learning									
8	Reading Research Quarterly	7	485	8	Reading Research Quarterly	377		8	Electronic Journal Of E-Learning	3171
9	Internet And Higher Education	8	463	9	ETR&D-Educational Technology Research and Development	348		9	Technology Pedagogy and Education	3129
10	Journal Of Literacy Research	12	431	10	Education and Information Technologies	337		10	Research In Learning Technology	2974

Note: P=Papers, TC= Total Citations, LS= Total Link Strength

When Table 3 is examined, it is seen that the Nordic Journal of Digital Literacy took the first place with a total of 2775 citations in 281 documents. This is followed by Computers & Education magazine with a total of 1874 citations in 36 documents. In the co-citation analysis, Computers & Education is in first place with 2000 citations, while Computers in Human Behavior is in second place with 636 citations.

A bibliographic matching analysis was conducted to identify the relationship between studies in the research area and to identify important studies. Here, it is tried to determine how often the two sources refer to each other and the extent of the interaction in the research area. As a result of the bibliographic matching analysis, it is seen that the journal with the highest link strength value is the Nordic Journal of Digital Literacy with a matching value of 27334. This is followed by Education and Information Technologies magazine with 10091 matches.

The Most Influential Authors Publishing on Technology, Digital, and Visual Literacy

Authors working in the field of technology, digital and visual literacy were examined and citation, co-citation, and bibliographic matching analyzes were performed to determine the most influential ones. The obtained findings are presented in Table 4.

Table 4. Comparison of Authors in Citation, Co-Citation, and Bibliographic Coupling

	Citation Analysis			Co-Citation			Bibliographic Coupling	
	Author	TC		Author	TC		Author	LS
1	Buckingham, D.	402	1	OECD	223	1	Erstad, O.	671
2	Mcgrew, S.	294	2	Gee, J. P.	212	2	Pedaste, M.	551
3	Coiro, J.	261	3	Kress, G.	206	3	Coiro, J.	486
4	Eshet-Alkalai, Y.	248	4	Buckingham, D.	200	4	Krumsvik, R. J.	470
5	Erstad, O.	247	5	Prensky, M.	186	5	Leijen, A.	399

	Citation Analysis			Co-Citation			Bibliographic Coupling	
	Author	**TC**		**Author**	**TC**		**Author**	**LS**
6	Krumsvik, R. J.	247	6	European, Commission	181	6	Maeots, M.	399
7	Burnett, C.	199	7	Selwyn, N.	179	7	Kiili, C.	383
8	Merchant, G.	196	8	UNESCO	179	8	Teichert, L.	363
9	Blau, I.	164	9	Lankshear, C.	171	9	Merchant, G.	345
10	Hatlevik, Ove E.	159	10	Erstad, O.	156	10	Blikstad-Balas, M.	314

Note: TC= Total Citations, LS=Total Link Strength

According to the Citation analysis data, Buckingham, D. has the highest number of citations (402). Other highly cited authors include McGrew, S., Coiro, J., and Eshet-Alkalai, Y. According to co-citation data, the organization with the highest number of common citations (223) is OECD. Authors such as Gee, J. P., Kress, G., and Buckingham, D. are also among the authors they often cited together. According to bibliographic coupling data, Erstad, O. has the highest link strength value (671). Authors such as Coiro, J., Krumsvik, R. J., and Merchant, G. are also among the authors with strong bibliographical links.

Main Topics of Research in Technology, Digital, and Visual Literacy

The examination of authors' keywords within their publications plays a critical role in identifying prevalent topics and offering valuable insights to researchers working in relevant fields (Song et al., 2019). Analyzing keywords allows for quick recognition of the content and main focus of a given article. The keywords of the studies published in the field of technology, digital and visual literacy were analyzed and the distribution of popular topics by year is given in Figure 3.
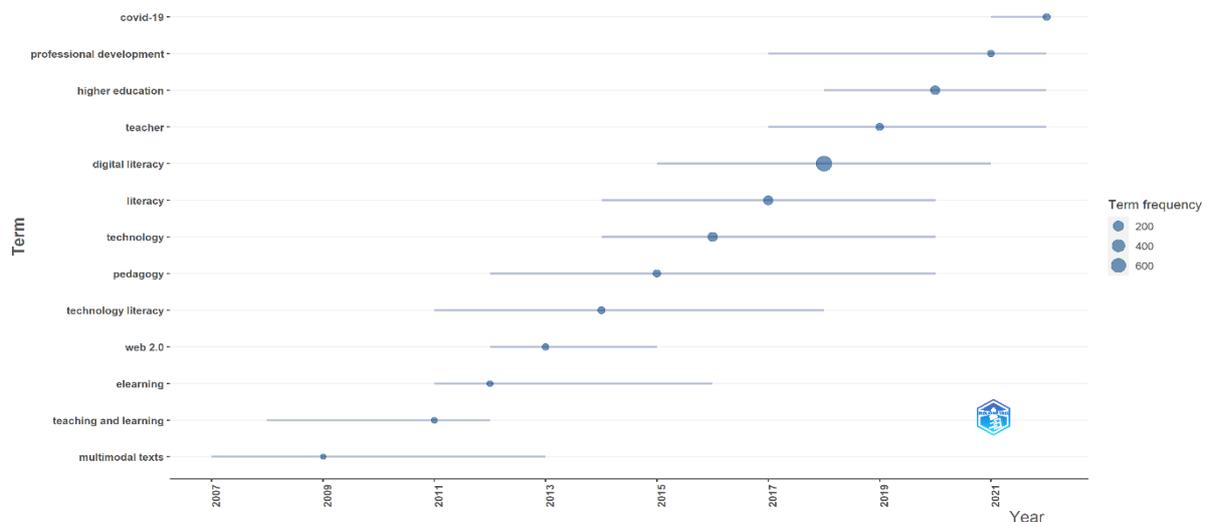

Figure 3. Trend Topic of Authors' Keywords

The lines in the graph indicate the years in which the relevant keyword was used, the location of the circles in which year it was popular, and the size of the circle indicates the frequency of use. It is seen that the term digital

literacy has been used increasingly since 2015 and is the keyword with the highest frequency (795). However, the term technology was used 129 times between 2014 and 2020, while the word Literacy was used 135 times between 2014 and 2020. In recent years, it is seen that the term covid-19 has become popular.

Thematic Clustering of Research on Technology, Digital, and Visual Literacy

In order to ascertain the author's level of skill in the pertinent study field and identify relationships between terms, co-occurrence analysis of author keywords entails reviewing the publication's content (López-Fernández et al., 2016). Finding subject areas (clusters) that can act as fundamental building blocks or research concepts was the main goal of this study (Manesh et al., 2021). Since author keywords are thought to offer a full representation of an article's content, they were chosen for co-occurrence analysis. The analysis of each article is essential given that the goal of this study is to uncover thematic clusters relating to technology, digital, and visual literacy. The clusters identified by the co-occurrence analysis and the associated keywords are provided in Table 5.

Table 5. The Clusters Obtained as a Result of the Co-Occurrence Analysis

Cluster	Keyword	OC	LS	Cluster	Keyword	OC	LS
1 (Red)	Technology	93	123	3 (Blue)	ICT	81	107
	Literacy	66	73		Digital Divide	44	59
	Media Literacy	42	72		Technology Literacy	36	24
	New Literacies	36	45		Teacher Education	35	41
	Pedagogy	33	56		Educational Technology	31	36
	Learning	32	38		Lifelong Learning	28	31
	Digital Technologies	31	25		Information Literacy	27	43
	digital literacies	30	26		Technology Integration	22	17
	Internet	29	44	4 (Yellow)	Digital Literacy	823	679
	Multimodality	28	36		Digital Competence	70	97
	Digital	25	38		Teachers	29	31
	Writing	23	35		Digital Storytelling	27	27
	Digital Media	22	26		Information Literacy	23	26
2 (Green)	Education	77	108		Primary Education	21	25
	Computational Thinking	37	26		Digital Citizenship	20	27
	Digital Skills	37	60	5 (Purple)	Higher Education	122	157
	Teacher Training	34	57		E-Learning	59	71
	Assessment	29	37		Online Learning	46	53
	Primary School	22	25		Social Media	46	54
	Curriculum	21	32		Blended Learning	38	44
	Digital Technology	20	22		Covıd-19	26	29

OC: Occurrences; LS: Total Link Strength

When Table 5 is examined, it is seen that author keywords are divided into 5 clusters as a result of co-occurrence

analysis. As seen in Figure 4, Figure 5, and Figure 6, other keywords are gathered around these five clusters. The most visible keywords of each cluster are cluster 1 - technology (93), cluster 2 - education (77), cluster 3 - ICT (81), cluster 4 - digital literacy (823), and cluster 5 - higher education (122). Since no single description can fully convey the richness of each cluster, this study seeks to offer a thorough justification for each one.
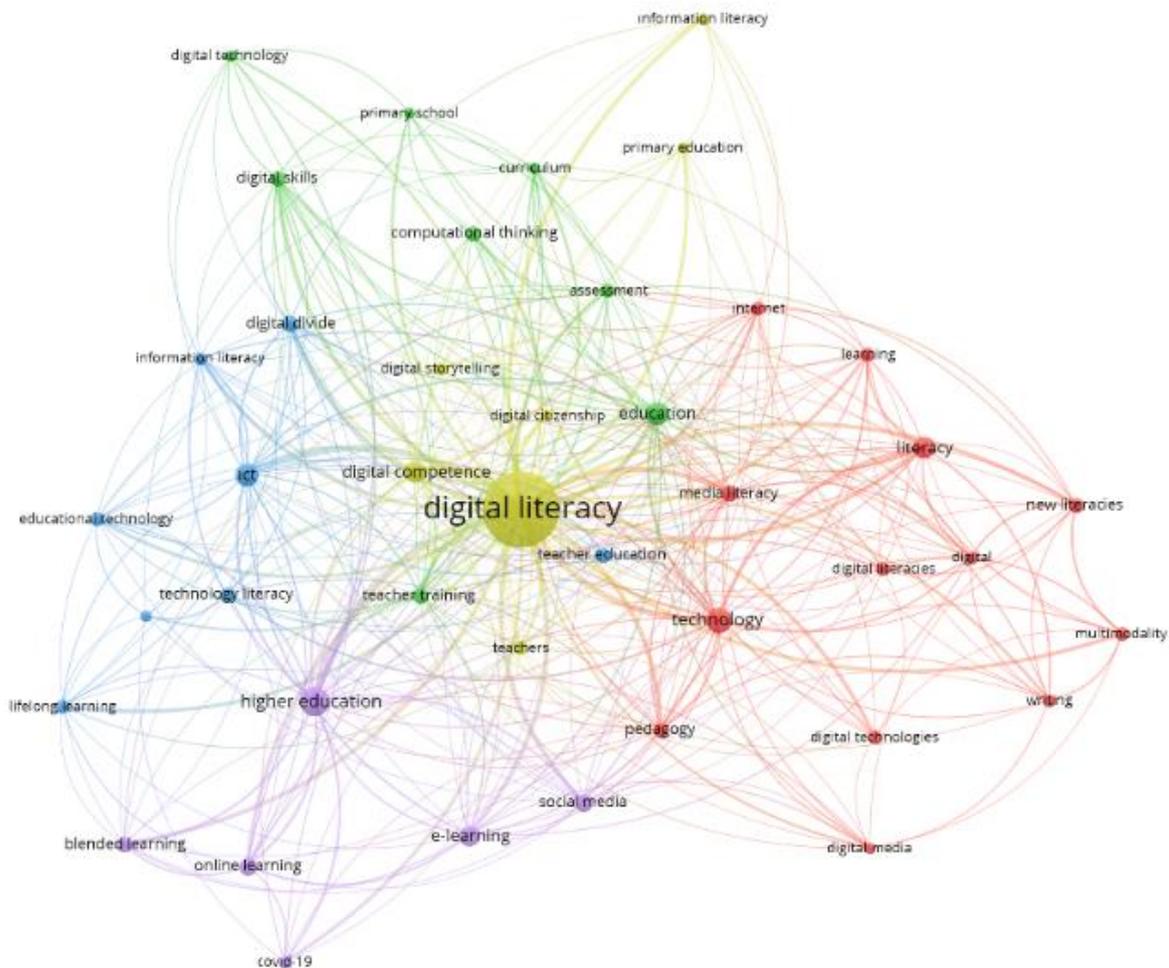
Figure 4. Network Diagram of Authors' Keywords Co-occurrences

The five thematic clusters are summarized here, and it provides an overview of the major subject areas that influence people's comprehension of technology, digital literacy, and visual literacy:

- Cluster 1: Keywords belonging to this cluster focus on digital topics such as digital technologies, digital literacy, media literacy, and multiple visualizations. Words such as literacy, media literacy, pedagogy, and technology are also included in this cluster.

- Cluster 2: Keywords from this cluster include education-related topics such as education, teacher training, assessment, computer thinking skills, and digital skills.

- Cluster 3: Keywords in this cluster focus on topics such as educational technology, information and communication technologies (ICT), information literacy, lifelong learning, and teacher training.

- Cluster 4: The keyword "digital literacy" is prominent in this cluster and has the highest citation count (823) and total link strength (679). In addition, topics such as digital citizenship, digital competence, and digital storytelling are also included in this cluster.

- Cluster 5: Keywords belonging to this cluster include topics such as higher education, online learning, blended learning, e-learning, and social media. In addition, the keyword "covid-19", which reflects the effects of the Covid-19 outbreak, is also included in this cluster.

The keyword co-occurrence network of the authors, in which each cluster is represented by different colors, is detailed in Figure 4. The size of the circles shown in the chart represents the frequency of occurrence of the relevant keyword.

Figure 5. Density Visualization of Authors' Keywords Co-occurrences

Figure 5 shows the usage density of each cluster as a result of the co-occurrence network analysis. The yellow colors in the graph show that the relevant theme is used extensively. The Density Visualization graph visually presents the density and distribution of keywords, helping researchers understand the differences and priority issues between clusters. When the graph is examined, it is seen that the keyword digital literacy is the most focused subject.

Finally, as a result of the co-occurrence analysis of the author keywords, the usage density of the relevant keywords over time is shown in Figure 6. It is seen that the keywords literacy and technology, expressed in dark blue, were popular in 2016, while the keywords higher education, online learning, and digital skills, expressed in yellow, became popular in recent years. Although it is used extensively, it is striking that the keyword digital

literacy was popular in 2018.

Figure 6. Overlay Visualization of Authors' Keywords Co-occurrences

Discussion

This study examined the literature in the fields of technology, digital literacy, and education using bibliometric analyzes and revealed important findings. At the beginning of the study, a disciplinary analysis was made and this analysis showed that the subject includes various disciplines such as education, information sciences, communication, and computer science. This highlights the importance of a multidisciplinary approach at the intersection between technology, digital literacy, and education. According to the results of the disciplinary analysis of the research in the field of technology, digital and visual literacy, education and information management are among the most concentrated disciplines. The Education Educational Research category makes up the majority of the articles reviewed, with a rate of 48%. This shows that the fields of technology, digital and visual literacy are mainly associated with educational research. This result shows that studies in these fields, especially in the context of educational research, have received great attention and these disciplines have contributed more than others. However, it is seen that Information Science Library Science and Communication categories also have an important share. These disciplines include studies in information management, librarianship, and communication. Other disciplines are represented by smaller proportions. These findings show that technology, digital and visual literacy are closely related to the disciplines of education and information

management, and research in this area is more focused.

As a result of the source analysis, the most cited sources were determined and focused on these sources. The sources published on the subject were analyzed in terms of citation analysis, co-citation, and bibliographic coupling. According to the Citation analysis data, the Nordic Journal of Digital Literacy is the journal with the highest number of citations (281). Computers & Education, Education, and Information Technologies, and the Journal of Research on Technology in Education are also important sources that are frequently cited among other journals. According to co-citation data, Computers & Education is the journal with the highest number of co-citations. Computers in Human Behavior, Computers & Education, the British Journal of Educational Technology, and the Nordic Journal of Digital Literacy are also commonly cited sources with other sources. According to bibliographic coupling data, the Nordic Journal of Digital Literacy has the highest coupling strength. Education and Information Technologies, Computers & Education, Digital Literacy: Concepts, Methodologies, Tools, and Applications, Vol and Literacy are also resources with a strong bibliographic link to other resources. These data show that resources such as the Nordic Journal of Digital Literacy, Computers & Education, Education, and Information Technologies, and Digital Literacy: Concepts, Methodologies, Tools, and Applications, Vol are important and influential in their respective fields. In addition, it is seen that resources such as Computers & Education, Computers in Human Behavior, and Journal of Computer Assisted Learning are frequently cited and jointly cited. These analyses enable us to understand the relationships between research and important studies in related fields. At the same time, high citation numbers show that relevant journals and publications include effective and important studies in their fields. The fact that they are considered as frequently referenced sources by researchers reflects the credibility and influence of these journals in the field.

Author analysis was used to identify leading researchers and publications in technology, digital and visual literacy. Authors such as Buckingham, D., McGrew, S., and Coiro, J. are noted for their high citation counts. This shows that these authors have made significant contributions to the field and are frequently referenced by researchers. In addition, organizations and authors such as OECD, Gee, J. P., and Kress, G. are similarly frequently cited names. These findings provide important clues to relevant researchers and academics by showing which studies and authors the field focuses on. In addition, it is thought that these findings can be used to identify trends and fields of study in the literature, to direct future studies, and to make new expansions in the field of research.

The keywords used by the authors in their studies were analyzed to determine the trends related to the subject. Based on the data obtained, it can be said that subjects such as digital literacy, technology, and literacy are constantly attracting attention and are popular. In addition, digital learning and technology-oriented topics such as e-learning and Web 2.0 are also seen to be important. Covid-19 has become a prominent issue in recent years and has attracted the attention of many researchers. These trend topics can be an important guide for researchers who will work in related fields. The keyword analysis results of this study provide important information about trend topics and focal points in education and technology.

Cluster analysis revealed the relationships and groupings between the keywords. The different clusters helped us to identify the themes and material issues of the relevant issues. For example, while keywords such as digital

literacy, media literacy, and multimodality were concentrated in one cluster, keywords such as pedagogy and technology came together in another cluster. This cluster analysis has guided us to identify the subject areas we can focus on in the field of technology and digital literacy in education.

Concepts such as digital literacy, technology, literacy, and e-learning are the topics that researchers are constantly working on. In addition, topics such as Web 2.0 and covid-19 seem to attract attention. Among the main reasons for reaching these findings is the increasing importance and interest in technology and digital literacy in the field of education. With the rapid development of digital technologies, the use of technology and digital skills in education is also increasing. This situation requires students and teachers to develop their knowledge and skills in the field of digital literacy. By focusing on these issues, researchers can develop strategies and approaches to support digital transformation in the education system.

On the other hand, newer topics such as higher education, online learning, and digital skills seem to be gaining popularity. This shows that digitalization has increased its impact in different areas of education and these issues are being investigated further. There is a need for greater focus in areas such as teaching methods, learning environments, and teacher training. These findings highlight the importance of research on technology, digital literacy, and related issues in the field of education. Based on these findings, educators can create policies, develop teaching strategies and focus on improving students' digital skills to support digital transformation in education. Also, focusing future research on these popular topics can help us further understand the impact of technology use in education.

In conclusion, this study emphasized the importance of technology, digital literacy, and education and revealed the trends in the literature. These findings encourage educators to do more research on digital literacy and technology use, focus their educational strategies on these areas, and work on improving students' digital skills. Also, focusing future research on these popular topics could further the impact of technology use in education.

Conclusion

This study revealed important findings related to bibliometric analyzes in the fields of technology, digital literacy, and education. Disciplinary analysis has shown that the subject encompasses several disciplines and requires a multidisciplinary approach. Source analysis has shown that journals such as the Nordic Journal of Digital Literacy, Computers & Education, Education, and Information Technologies are influential and cited in the literature. Author analysis revealed that researchers such as Buckingham, D., McGrew, S., and Coiro, J. were prominent names. Trend analysis has shown that topics in digital literacy, technology, and education are gaining popularity and are of increasing importance. Cluster analysis, on the other hand, guided us in determining the themes and priority issues of the relevant topics.

These findings encourage educators to do more research on digital literacy and technology use, focus their educational strategies on these areas, and work on improving students' digital skills. Also, focusing future research on these popular topics could further the impact of technology use in education.

In conclusion, this study emphasized the importance of technology, digital literacy, and education and revealed the trends in the literature. The findings of this study guide researchers and educators and provide direction for future work. It is expected that research in technology and digital literacy will support the development of education and contribute to equipping students with skills appropriate to the needs of the age.

Recommendations

Given the findings and analyses of this study, the following recommendations may be valuable to researchers and educators:

- Digital literacy has become one of the most basic skills of students in a world where technology is developing rapidly. Educators should provide more resources and educational materials for the development of digital literacy skills, and support students to gain effective communication, information-seeking, and critical thinking skills in the digital world.
- Our findings show that technology plays an important role in education. Educators should have access to more technology-based tools and resources to enrich the learning experiences of technology, increase student engagement, and offer approaches suitable for different learning styles.
- Teachers should have up-to-date knowledge and skills in digital literacy and technology use. Educational programs should enable pre-service teachers to gain competence in digital literacy pedagogy and effective technology integration.
- The results of this study encourage collaboration and knowledge sharing among relevant researchers, educators, and stakeholders. Activities such as attending relevant conferences, presenting articles to journals, and organizing seminars will increase the sharing of knowledge and experience.
- The findings of this study provide a roadmap for future research. Future work may focus on areas such as digital literacy education, technology integration strategies, teacher education models, and assessment of students' digital skills.

These recommendations aim to ensure that research and applications in the field of education are more effective and that students are ready for the age of technology. In a world where digital literacy and technology use are increasing, educators must pay attention to these issues and develop students' digital skills.

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