PERINATAL JOURNAL

Original Article

Perinatal Journal 2025; 33(1):423-437

https://doi.org/10.57239/prn.25.03310049

Global trends and research frontiers in digital literacy research: A scientometric analysis with citespace (1990-2024)

Hongnan You[1], Sheiladevi Sukumaran[1]*, Lei Song[2], Xiaomin Zhi[2], Lihua Li[3], Dongping Wub[3]

[a]School of Foreign Languages, Jiangxi Agricultural University, Nanchang, Jiangxi Province, China
[b]School of Chemistry and Materials, Jiangxi Agricultural University, Nanchang, Jiangxi Province, China
[c]Faculty of Education, Language, Psychology, and Music, SEGI University, Kota Damansara, Selangor, Malaysia
[d]International Education School, Sichuan International Studies University, Chongqing, China

Abstract

Digital literacy is a rapidly developing and crucial skill set, essential for achieving Sustainable Development Goals (SDGs), particularly SDG 4 (Quality Education) and SDG 10 (Reduced Inequalities) by bridging the digital divide. This study provides an overall view of global research on digital literacy and explores the key trends in publications and citations from 1990 to 2024. A total of 9,042 bibliographic records were retrieved from the Web of Science Core Collection and analyzed using CiteSpace. Through a scientometric analysis that included keywords co-occurrence, reference co-citation, and timeline views, the study identified global trends and research frontiers. The results show that the USA, the University of London, and the journal Computers & Education rank as the top contributors in their respective categories. Analysis of keyword citation bursts highlights "new literacies," "media literacies," and the "digital divide" as key research frontiers during their periods. These findings offer important insights into the evolution of digital literacy research, providing foundational support and constructive guidance for researchers and educators. By understanding the historical and emerging trends, this study provides a roadmap for developing effective strategies to enhance digital literacy, thereby supporting more equitable and high-quality educational outcomes in line with the global SDGs.

Keywords: Digital literacy, Scientometric analysis, CiteSpace, Research trends, Research frontiers, Sustainable Development Goals (SDGs), SDG 4, SDG 10

Introduction

With the emerging forces of new media, internet, digital products, computers and computer software, some scholar keenly captured a new sort of literacy, Digital Literacy (DL), and had some works to introduce and discuss DL. These works included Gilster's book, Digital Literacy, among the first to use this term to define: “Internet users, people who discover and evaluate content before deciding to put it to work” (1997, p. ix). This book offers a version of a highly functional view of digital literacy, which also lays a basis for the systematic conception of digital literacy concept and scheme in this paper (Gilster & Glister, 1997; Jam et al., 2025).

When almost everyone admits that in 21st century a new set of skills related with new technologies, new media, and internet are necessary for literacy, there is little consensus about precisely what knowledge and abilities are necessary for people to be digitally literate (Ba et al., 2002). Many scholars have their own understanding of digital literacy and set different definitions, theories and theoretical frameworks. Prensky's (2001) essay defines digital natives as students inherently skilled in technology use. This essay has been cited over 20,000 times, according to Google scholar, albeit often in challenge. Nevertheless, it remains the subject of much, continued reanalysis and critique (Bawden, 2008; Bennett et al., 2008; Eshet, 2004; Martin & Grudziecki, 2006). Later, using terms like mindsets, identities, and ways of being in the world (Gee, 1991; Knobel & Lankshear, 2004), Lankshear and Knobel (2004), along with other new literacy scholars (Coiro, 2003; Coiro et al., 2014a, 2014b; Cope & Kalantzis, 2009; Leu et al., 2008), advance what has been termed a sociocultural view of digital literacy.

Over the past decade, especially during and after the COVID-19 pandemic, the digitalization process in the field of healthcare has changed rapidly, and more and more scholars have paid attention to digital health literacy, which is gradually becoming a hot field of digital literacy. Responding to the needs of The Times, Rosalie van der Vaart (Van Der Vaart & Drossaert,

Correspondence: Sheiladevi Sukumaran, School of Foreign Languages, Jiangxi Agricultural University, Nanchang, Jiangxi Province, China, **e-mail:** sheiladevisukumaran@segi.edu.my, **Received:** June 26, 2025 **Accepted:** August 3, 2025

2017) has developed a new tool, the Digital Health Literacy Tool (DHLI), which uses multiple subscales to comprehensively measure health 1.0 and health 2.0 skills as a new self-reported measurement tool for assessing digital health literacy. With the advent of AI and ChatGPT, the application of artificial intelligence in various fields has grown exponentially, and AI has become a new research topic for DL.

The research significance of DL is reflected in the emergence of new trends in interdisciplinary research and technology-assisted teaching, as well as the steady increase of DL from scratch three decades ago to steady increase in the past ten years, especially the sharp increase in publications in the last five years (see Figs. 1 and 2, and section 2.1), which indicates that this field is an emerging field and has become a hot topic for researchers in recent years. There is still great room for development in this field. Therefore, it is both realistic and necessary to discuss DL and offer researchers a systematic grasping and overview of its global trends, and provide future researchers with new perspectives in frontier fields.

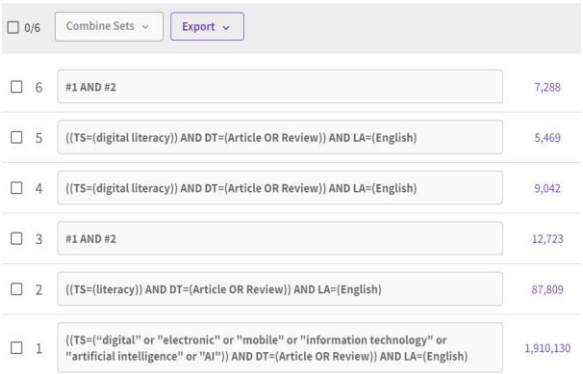

Figure 1. Topic search queries on DL

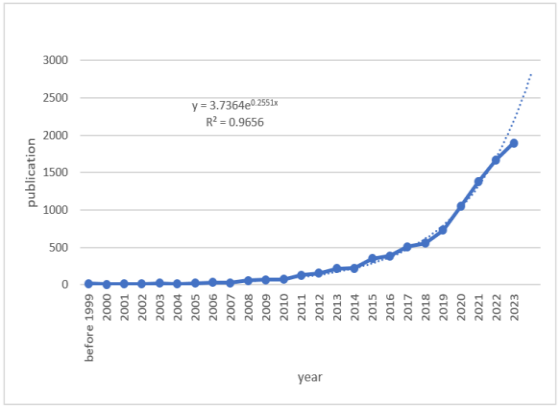

Figure 2. Publication of DL over time (1990-2023)

The literature search and topic search queries revealed that very few reviews have been reported on DL(Stopar & Bartol, 2019; Tian & Park, 2023; Wang & Si, 2023), especially through a bibliometric analysis such as CiteSpace or VOSviewer, although there has been a burst of research interests in DL and a large number of articles (Audrin & Audrin, 2022; Buchholz et al., 2020; Falloon, 2020; Li & Yu, 2022; Liu et al., 2020; Oh et al., 2021; Purnama et al., 2021; Sá et al., 2021; Veronika et al., 2023; Yeşilyurt & Vezne, 2023) are published each year from 2020 to 2023, over 1000 articles and reviews per year. However, although these studies are carried out through systematic bibliometrics, some articles (Park et al., 2020; Stopar & Bartol, 2019; Jam et al., 2016) are about the DL and other perspectives of literacy, which explores some perspectives of literacy and their relationship with DL. Wang & Si (2023) combined the topic of DL with COVID-19 pandemic and made a bibliometria analysis. Only Tian & Park (2023) made a rather systematic analysis and visualized the research development and hotspots of DL, while this research is only limited to the field of education and learning.

Against this background, we use scientometric analysis, with a visual analytic tool CiteSpace, and knowledge network visualization for analyzing trends and patterns in the scholarly literature of DL. By analyzing the country distribution, institution distribution, author distribution and journal distribution, this paper will show an overall view of the global research in DL and explore the overall trends in publication and citations in DL research. With CiteSpace, this paper will do the keywords co-occurrence analysis, reference co-citation analysis, categories co-occurring analysis, term and cited references analysis, showing the science mapping of clusters, timeline view, etc. to generate a variety of visualizations and map the knowledge structure of the research in DL, and to explore the research frontiers or emerging trends of DL research. To the best of our knowledge, this would be the first comprehensive and exhaustive scientometric analysis, which covers all literatures in DL from the very beginning to the date this study was carried out, and this study can offer basic and important support, provide constructional guidance for researchers and educators in the future.

The research questions of this paper are addressed as

follows:

(1) What are the global trends in publications and citations of DL research?

(2) What are the research frontiers in the field of DL?

Methods

Data collection

This study adopted the core collection of WoS as the data source. The retrieval method follows the steps described in Chen (2017), with combined multiple search queries (Fig. 1). The data were searched on February 19, 2024. The specific screening strategies and procedures are shown in Fig. 1. TS means the subject tag used for searching string retrieval. The document type (DT) was limited to "Article" or "Review", and language (LA) = English was selected to exclude the other languages and refine the searching results. In this way, the first query generated 1,910,130 as Set #1 and the second query produced 87,809 records as Set #2. The third query combined Set #1 and #2 with the combining choice "AND" not "OR", to make sure both keywords of the sets were covered. This query led to 12,723 records as Set #3. The fourth query came out 9042 records as Set #4. The queries #5 and #6 aim to retrieve records with query #4 and #3 respectively, with new time limitation, narrowing the publication date to "Last 5 years".

From the topic search queries data (Fig. 1), it can be estimated that since 1990s the term "digital literacy" was put forward and till now altogether 9042 articles and reviews have been published, among which the articles and reviews in the last 5 years, altogether 5469, occupied the large percent, up to 60%, of the total number. Thus, publications on DL are presented before 1999 to 2022 (Fig. 1). As shown in Fig. 1, the solid line shows the exact trend of publications, and the dashed line shows the trend of publications in the form of an index. It is clear that DL publications, including articles and reviews, are growing exponentially in general. According to the Price Curve. developed by Derek John de Solla Price (1922-1983), the exponential growth of publications in a field indicates that the field is not yet saturated and that there is still room for growth.

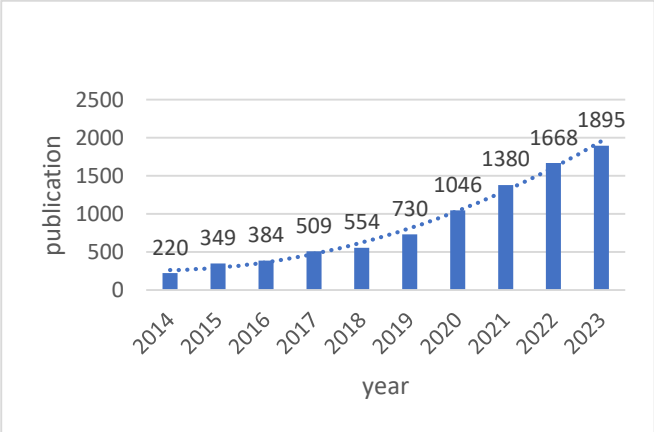

Figure 3. The distribution of the records from 2014-2023

A total of 9042 records all years and 5469 records in last 5 years, of "Article" or "Review" document type and LA in "English", were retrieved respectively. All these records were downloaded for data analysis.

Visualization and analysis

Bibliometric analysis was first proposed by Pritchard and he described it as "the application of mathematical and statistical methods to articles and other forms of communication" (Pritchard, 1969; K. Yang et al., 2022). Bibliometrics is an information analysis method to obtain quantifiable objective data by measuring the research trend and knowledge structure of a certain field (Guo et al., 2020). CiteSpace enables recent advances in general methods for detecting and visualizing emerging trends and transient patterns in the scientific literature(Chen, 2006, 2017). In addition, it can also carry out literature co-citation analysis, make national cooperative network analysis, co-keyword analysis and citation bursts analysis according to literature data. Keyword cluster mapping can reflect the research hotspots, and the citation bursts can show the research trends.

In this study, the dataset was analyzed and visualized with the visual analysis software CiteSpace, with the latest version 6.3.R1 (64-bit) Advanced, which was built on February 18, 2024. It will do national cooperative network analysis, keywords co-occurrence analysis, reference co-citation analysis, categories co-occurring analysis, term and cited references analysis, showing the science mapping of clusters, timeline view, landscape view, etc.

Results and Discussion

In this section, the results of the analysis of overall trends in publication and citations, research frontiers and emerging trends are discussed and presented.

Global trends in publications and citations

DL findings has been dramatically expanding since 2020 and DL research is growing by leaps and bounds, entering a new phase of rapid growth. In the last 5 years, until February 19, 2024, the date of collecting data in the core collection of WoS for this study, the largest number of articles in this period were published, 5469, accounting for more than 60% of all articles throughout the recent 20 to 30 years. Thus it is very important to count the total data of last five years and this period can be more clearly demonstrate the overall trends and scholars' interests in DL, to be more concentrated and with less distraction. This total number of 5469 publications were adopted in this part to discover the overall trends of DL research.

Countries distribution

A visual analysis of country collaboration was conducted to identify the countries which are engaged in the research of DL and the key countries greatly contributing to digital literacy. Altogether, 129 countries have been engaged in and conducted the research in DL (Fig. 4). Fig. 4 and Table 1 also show the ranking of the top 10 countries with publications more than 145 articles. These top ten countries are USA, Australia, People's Republic of China, England, Spain, Germany, Canada, India, Netherlands and Italy. The United States ranked as the first with 1208 articles, accounting for 22.08% among the total, which shows the predominant position of USA in the study of DL. Australia and People's Republic of China rank as the No2. and No3., with 450 and 440 articles respectively, showing rather small gap in publication number, each making up about 8% global publications. England and Spain follow up, with 417 and 392 publications respectively. The top 10 countries accounted for a total of 3,947 articles, or more than 72% of the total published articles, indicating that most of the research on this issue is concentrated in these countries and regions.

Figure 4. National cooperation in the field of DL in last 5 years

Table 1. Top 10 publication countries/regions (N=5469)

Number of Articles	Percentage	Centrality	Countries/regions
1208	22.08%	0.11	USA
450	8.22%	0.10	AUSTRALIA
440	8.04%	0.03	PEOPLES R CHINA
417	7.62%	0.16	ENGLAND
392	7.17%	0.08	SPAIN
286	5.23%	0.08	GERMANY
276	5.05%	0.03	CANADA
177	3.24%	0.10	INDIA
155	2.83%	0.07	NETHERLANDS
146	2.67%	0.06	ITALY

The centrality of a node represents the frequency at which it acts as the shortest bridge between the other two nodes. In addition, the more frequently a node acts as an intermediary, the greater its centrality. The character size of a node usually indicates its importance or prominence in the network. Larger characters might represent highly cited papers, influential researchers, or key concepts (Chen, 2006, 2017). From the character size in Fig. 4 and information in Table 1, it can be judged that the

United States, which owns the most publication and the second top centrality (0.11), are dominant in the research of DL. And there is one particular statistic needing mentioning, that is, although England ranks fourth, only with 417 publications, the centrality of England is even higher than USA, ranking No. 1 in the list of countries. The implication is that some renowned institutions or researchers in England published some prominent and most influential articles in last 5 years. Both Australia and India have the same centrality of 0.10, while Australia ranking No.2 with a total of 450 publications and India ranking No. 8 with only 177 publications. The research in India shows its own importance and unique contribution in the research of DL. China published the third most articles (440) but with rather low centrality (0.03), which means China need to cultivate more talents and more influential scholars who will do more contributions in the research of DL.

Institutions distribution

To a certain extent, the number of published papers of research institutions reflects the research capability of the institution, and the statistical analysis of the quantity and quality of published papers of research institutions can better reflect the development process and research achievements of each research institution (Danni et al., 2018; Huang et al., 2023). Using CiteSpace, this study further analyzes the research institutions in the field of DL and their cooperative relationships, and obtained the institutional cooperation network visual mapping (Fig. 5). As can be seen from Fig. 5, the linkages among institutions are strong and they could be more robust where a low level of institutional collaboration in this area of research exists. Fig. 5 visualizes the top 10 institutions that published the most papers in DL in last 5 years. In the top 12 institutions contributing the most papers, only one is a research institution, the national administrative department in education and science—Ministry of Education and Science of Ukraine, and the rest are higher education institutions (Tab. 2), highlighting the importance of higher education institutions in the field of scientific research and DL.

Fig. 5 shows the top 10 institutions (11 in total because 2 institutions are tied for the tenth place) publishing the most papers and signifies their importance in the research of DL. The University of London is ranked first, the University of California System is the second, followed by another famous university Harvard University. Among these top 10 institutions, 1 is from UK, 4 are from US, 3 from Austria and 2 from Canada. Except one institution from Ukraine, all these top 10 institutions are famous universities which enjoy high prestige and share profound foundation in doing research. University of London is a famous federated university comprising colleges and institutions in London and is particularly renowned for humanities, medicine and computer science. University of California System, one of the top public university systems in the US, is famous for its research in engineering, medicine and economics. The third ranking institution Harvard University is one of the most prestigious and oldest private universities in the US and is renowned throughout the world for its supreme education and research. 3 other universities of the US are top public universities, which means they can get plentiful funds from the state government and federal government, share abundant resources in education and research, and have advantaged predominance. Similarly, the top institutions from Australia and Canada enjoys such advantages, such as University of Melbourne and University of Sydney, leading and oldest public universities in Austria, University of Toronto and University of British Columbia, leading and top-ranked universities in Canada. The 10th institution, Monash University, is also a major public research university in Australia and share high reputation in medicine, engineering and economics. Another one institution, following the top 10 immediately, University of College London is worth mentioning. It is also a leading public research university in the UK and does great contributions in the study of DL, helping the UK, with highest centrality (0.16) throughout the world as mentioned above, become the research center of DL globally.

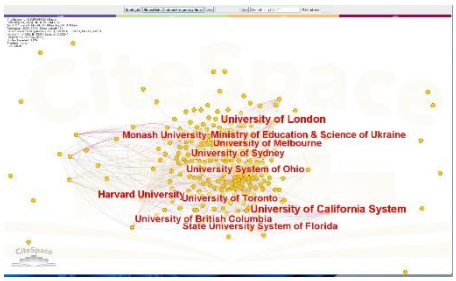

Figure 5. Top ten institutions in the field of DL in last 5 years

Table 2. Top 12 institutions in publications of DL (N=5469)

Number of Articles	Centrality	Institution	Location	Countries/regions
97	0.15	University of London	London	UK
94	0.15	University of California system	California	USA
62	0.13	Harvard University	Massachusetts	USA
54	0.05	University System of Ohio	Ohio	USA
52	0.08	University of Melbourne	Melbourne	Australia
52	0.06	University of Sydney	Sydney	Australia
52	0.07	State University System of Florida	Florida	USA
51	0.08	University of Toronto	Toronto	Canada
51	0.05	University of British Columbia	Vancouver	Canada
50	0.01	Ministry of Education & Science of Ukraine	Kyiv	Ukraine
50	0.08	Monash University	Melbourne	Australia
48	0.05	University College London	London	UK

Cited authors distribution

In the last 5 years, 5469 bibliographic recordings were displayed. Considering the date for collecting data for this study was February 19th, rather early in 2024 and it is not so full or suitable to fix 2024 in, this study chooses to use the CiteSpace and doing co-citation documents analysis, setting the timespan from 2020 to 2023 and a 1-year time slice. The most frequently occurring or quoted articles were chosen to find out the most influential and important articles and their authors. The most prolific authors are different with the most-cited authors. The most prolific authors refer to the authors in terms of their publication number, while the most cited authors mean the authors whose total citation frequency are highest and show the great influence in the field. The most productive authors do not always consistent with their ranking in terms with their influence.

In order to represent cited publications and co-citation relationships across the entire data set and find out the most cited authors, the node types were set twice. For the first time "cited author" was chosen in the node type setting, but the visual mapping was complicated, with the first ranking 2830 UNKNOWN cited authors, not feasible for explaining deeper. For the second time "references" was chosen, the visual mapping showed 519 distinct nodes (N=519) and 2155 links (E=2155), with density 0.016, very weak correlation between papers. The visual mapping (Fig. 6) and Table 3 list the top 10 articles and their authors that have received the most citations in the research of DL.

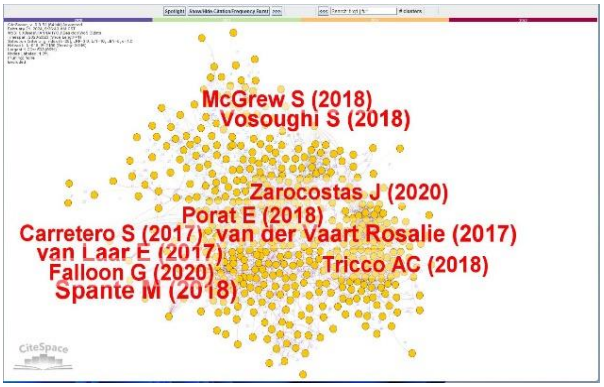

Figure 5. Top ten institutions in the field of DL in last 5 years

Table 3. Top 10 most cited articles and the authors in DL

Citation counts	Centrality	Year	Author	Country
72	0.06	2018	Spante M	Sweden
61	0.05	2017	Van Laar E	Netherlands
56	0.08	2017	van der Vaart Rosalie	Netherlands
51	0.03	2018	Vosoughi S	USA
45	0.11	2020	Zarocostas J	Australia
45	0.01	2017	Carretero S	Spain

44	0.02	2020	Falloon G	Australia
44	0.08	2018	McGrew S	USA
44	0.08	2018	Porat E	Israel
44	0.00	2018	Tricco AC	Canada

Spante M et al.(2018) conducted a systematic review of the concepts and application of digital competence and digital literacy in higher education research, aiming to understand the reference strategies for digital competence and digital literacy in different periods and disciplines throughout various countries. This review also suggests the way for further research in the field of digital competence and digital literacy in higher education. Van Laar E et al. (2017) has made a systematic literature exposition on the concepts of 21st century skills and digital skills. The study aims to provide a 21st century digital skills framework by examining the relationship between 21st century skills and digital skills, including conceptual dimensions and key operational elements for knowledge workers. This paper summarizes the 75 academic literature from 1592 articles related to 21st century digital skills and it turns out that the range of 21st-century skills is broader and covers far more comprehensive than that of digital skills. Van der Vaart Rosalie & Drossaert (2017) studied another theme, Digital health literacy. This study develops the Digital Health Literacy Instrument and tested the Broad Spectrum of Health 1.0 and Health 2.0 Skills, according to the distribution characteristics, reliability, content validity and structural validity of its self-report scale (21 items). And at last it demonstrates this instrument can be accepted as a new self-report measure to assess digital health literacy. Vosoughi S et al. (2018) studied the spread differences between true and false news which had been all verified and posted on Twitter from 2006 to 2017. He found that fake news was more unusual than real news and people were more willing to share uncommon and rather novel information, which directly caused fake news to spread more widely than true news. The survey also found, robots sped up the spread of true and fake news at rather fast rate. Fake news is easier to spread than real news because it is more likely to be spread by humans, not robots. The Australian journalist John Zarocostas (2020) released a report on February 29, 2020 when epidemic spread over the certain countries, and he cited the words by WHO Director-General Tedros Adhanom Ghebreyesus at the Munich Security Conference on Feb 15. He addressed that WHO and world were not just fighting an epidemic, but fighting an infodemic, because people were inclined to pick the most extreme pictures they got and published everywhere through a variety of ways, sending the wrong messages consciously or unconsciously.

In this section, co-citation literature analysis was used to find key references, identify important authors, and track research hotspots of these high-cited publications. From these high-cited articles and reviews, we can figure out that digital competence, digital skills, digital competence framework, measuring ways of digital literacy are mainly concerned by scholars since these are regarded as the basics of DL research. And the breakout of epidemics and COVID-19 pandemic in recent years also intrigued the great development of new study fields in DL, such as fake news study and digital health literacy study. The online sources of digital learning and diverse choices of digital literacy participants between students and teachers are also the hotspots of researchers.

Journals distribution

The 5469 citing articles in this paper are from the total of 1071 different journals. Fig.7 shows the top 30 journals, ranked by number of citations, and reports their total citations and their centrality. If we rank journals based on the number of articles published, we find that their citations do not coincide with their ranking. Some journals have relatively high citations despite publishing relatively few articles. The number of citations indicates that some journals are cited more frequently than others, which may reflect the relatively better quality of their publications.

As shown in Table 4, in terms of the cited publication number, the top 10 cited journals are Computers & Education (from UK), Journal of Medical Internet Research (from Canada), Computers in Human Behavior (from UK), PLOS ONE (from USA), New Media & Society (from UK), International Journal of Environmental Research and Public Health (from Switzerland), Frontiers in Psychology (from

Switzerland), British Journal of Educational Technology (from UK), Education and Information Technologies (from Netherlands), and Sustainability (from Switzerland). All these journals are of supreme quality in publishing articles, with excellent reputation and high citations. Among the first three journals, Computers & Education is a journal evaluating impacts and effects of computers in education and specializes in educational technology, computer-assisted learning. Journal of Medical Internet Research focuses on internet and new media applications in healthcare, and Computers in Human Behavior explores interactions between computer technology and human behavior. Among these top 10 cited journals, 4 journals are from England, 1 from USA, 1 Canada, 3 Switzerland and 1 Netherlands. And searching for the top 20 cited journals, we find 10 journals are from UK, 4 journals from USA, 1 journal from Canada, 3 journals from Switzerland, 1 journal from Ireland and 1 journal from Netherlands.

In the cluster mapping, if a node is of large size and is surrounded by a purple ring, it highlights its core status: CiteSpace uses purple rings to emphasize and highlight the special importance of this node, making it more visible and prominent in the overall science mapping. In Fig.7, three nodes are of the largest size and all are circled with purple rings, which are Computers & Education, Journal of Medical Internet Research, and Computers in Human Behavior. Being the biggest nodes and being circled with purple rings means these three journals are the most influential journals in the publication of the study of DL. All these three journals are also with highest centrality, Computers in Human Behavior, Journal of Medical Internet Research, and Computers & Education rank from No.1 to No.3, with the centrality value 0.29, 0.19 and 0.15 respectively.

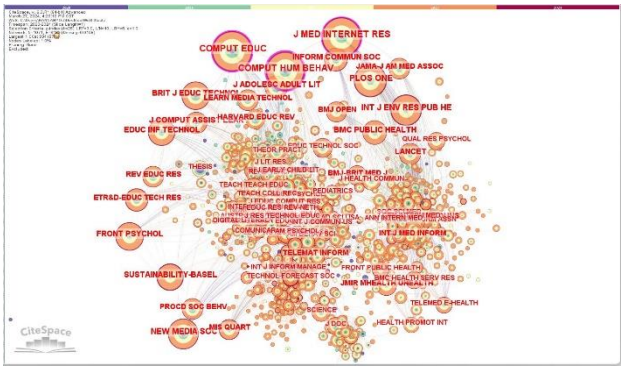

Figure 7. Top cited journals in DL

Table 4. Top 10 most cited journals in DL

Citation counts	Centrality	Year	Cited Journals	Country
1288	0.15	2020	COMPUT EDU	UK
1217	0.19	2020	J MED INTERNT RES	Canada
1154	0.29	2020	COMPUT HUM BEHAV	UK
867	0.05	2020	PLOS ONE	USA
744	0.03	2020	NEW MEDIA SOC	UK
726	0.09	2020	INT J ENV RES PUB HE	Switzerland
623	0.07	2020	FRONT PSYCHOL	Switzerland
618	0.02	2020	BRIT J EDUC TECHNOL	UK
586	0.04	2020	EDUC INF TECHNOL	Netherlands
586	0.03	2020	SUSTAINABILITY-BASEL	Switzerland

To draw a conclusion, in terms of the cited publication number, the top 3 cited journals are *Computers & Education, Journal of Medical Internet Research, and Computers in Human Behavior. According to the centrality value of journals, the top 3 cited journals are Computers in Human Behavior, Journal of Medical Internet Research, and Computers & Education*. No matter from which perspectives, we can see that these three journals are of extreme importance and lead the study of DL. These are high frequently cited journals also explain why the highest centrality of all countries doing the research in DL are UK and USA, and England (centrality 0.16) is even higher than USA (centrality 0.11), ranking top in the list of countries.

Research frontiers

Considering that the origin of digital literacy research can be traced back to 1990s and the research of DL

flourishes and develops rapidly in the recent 10 years, this part included references with the keywords of DL from 1978 to 2024, hoping to cover all references about DL and literacy, comprehensively and intuitively present an overall topic structure and dynamic evolution of the literature dataset.

Citation bursts

Keywords are of great and crucial importance to reveal the changes and trends of the research development since keywords can directly manifest the changes and new occurrences (Li et al., 2008; K. Yang et al., 2022). Research frontier refers to terms that appear in a short period of time with a rapid increase in frequency (Zhang et al., 2024; NS et al., 2025). The term burst means a sudden increase in the reference intensity of a term, which can reflect it has attracted more attention and newer research directions. Burst words has the function of sorting out regular changing words in various subject words and the words found as the main index to determine whether they are the forefront in a certain period. In order to better understand the emerging trends and research frontier of the research topics, this study uses CiteSpace to analyze the keywords with strong citation bursts. The time span was set from 1992 to 2024. A high Strength value means that the keyword is used very frequently and the topic is very hot and prominent during that period.

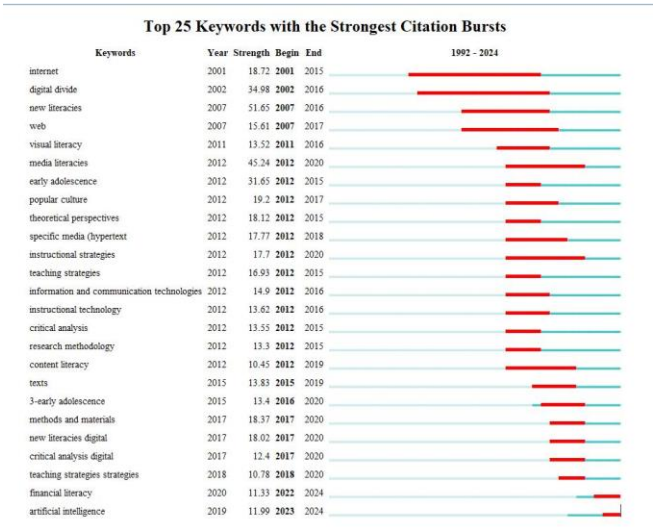

Figure 8. Top 25 keywords with the strongest citation bursts

As shown in Fig.8, the mapping of top 25 keywords with the strongest citationbursts, these 25 keywords can be regarded as the hot issues of DL. *New literacies* has the highest strength value 51.65, then *media literacies* (strength value 45.24) follows, and then *digital divide* (strength value 34.98) and *early adolescence* (strength value 31.65). When the strength value exceeded 30, it indicates that these keywords had very high significant strength and importance during their citation burst outburst, and could be regarded as the absolute core hot topics in this stage. In particular, the key word whose strength is as high as 51.65 can be regarded as the undoubtedly dominant research topic in this stage, and the hottest and core focus of academic discussion. These four sets of keywords could be taken as the absolute core during their periods. Compared with most general hot topics with strength values ranging from 10 to 20, these keywords with high strength values are more prominent and attract more research attention, representing the most concentrated and active discussions in this field. All the other keywords have the strength value between 10 to 20, indicating that these keywords have relatively high significant strength during their citation burst outburst. This range of values usually represents a medium to high intensity level for a hot topic of study. No keywords strength value is below 10. The strength value of no node is too low (for example, less than 5), indicating that in this prominent stage, the keyword topics presented have received a certain degree of research attention, and no topics are too marginal

Burst duration time is another helpful signal for analyzing the duration, the evolution, and the popularity of the topics. From the citation burst detection, it can be figured out that 3 sets of keywords (*internet, digital divide, web*) burst duration are over 10 years (14 years, 14 years, 10 years respectively), and these can be considered long-term core themes in the field. These long-term hot spots reflect the deep-rooted research and are likely to become classic research directions in the field. Other 7 sets of keywords burst duration are between 5-9 years and they are *new literacies, visual literacy, media literacies, popular culture, specific media hypertext, instructional strategies,* and *content literacy*. If the citation burst duration of a keyword is around 5-9 years, it indicates that it is a hot research topic of relatively medium duration. More than 5 years can be considered a relatively mature and widely appreciated topic. The other 60% keywords, 15 sets, own the duration time about 2-4 years. The shorter duration of the subject

2-4 years represents the short-term hot spots and small-range hot spots. Some topics, due to their particularity or narrow scope, have attracted attention in the short term, but the heat is relatively difficult to sustain. Such topics have a limited reach. However, two short-time sets of keywords are worth mentioning—*financial literacy* and *artificial literacy*. *Financial literacy* appeared as early as 2020 and the burst duration began since 2022 till this year, which fits the global atmosphere of economy and financial situation. *Artificial literacy* emerged in 2019 and the burst duration started since 2023, which also suits the great happenings of AI in 2019 and 2023. Whether it is the breakthrough progress in 2019, or the increasingly extensive application landing and challenges in 2023, these two years have become extremely critical and important nodes in the development process of artificial intelligence. These two new sets of keywords are with rather short duration but have strong strength value over 10, which strongly reflects these may be emerging frontiers worthy of high attention in the future.

In conclusion, when the keyword visualization map of citation bursts is generated, the strength value reflects the core status and representative strength of a specific keyword during its prominence period, and is an important reference to judge the popularity of the topic. Combined with the time dimension, we can more accurately grasp the evolution of the topic and the transfer process of the research hotspots in a certain field.

Timeline view and high-cited references

To analyze the evolution of knowledge in the DL domain and find out the research frontiers, a timeline visualization of co-cited terms and references was generated by CiteSpace (Fig. 9). The timeline visualization in CiteSpace illustrates clusters along a horizontal timeline. Colored links in the figure show connections among nodes and clusters. The nodes are colored either in red or a spectrum of colors. The size of the circle corresponds to the citation counts and central influence of the reference in the field. The larger the circle, the more frequently the document is cited and the higher its central position in the knowledge network (Chen, 2006, 2017). Such oversized circle nodes often correspond to famous literature, theories, or ideas that are groundbreaking or landmark in the field. They have laid the research foundation of the field and had a profound impact on the subsequent development. If this super-large node is surrounded by a purple ring, it highlights its core status: CiteSpace uses purple rings to emphasize and highlight the special importance of this node, making it more visible and prominent in the overall timeline view. The purple ring usually represents a literature or theory that has had a long-term and sustained significant impact on the field and is the core knowledge base throughout.

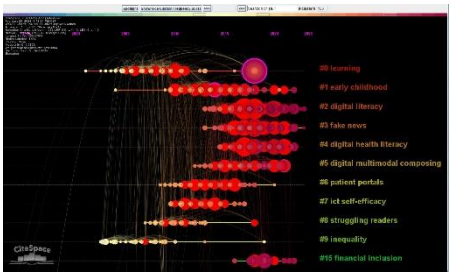

Figure 9. A timeline visualization of major co-citation clusters of terms and references

To build a network of references cited that year, the top 50 most cited publications each year are used, the scale factor g-index (k)is set 25, 10.0% of most cited or occurred items from each slice are chosen, and the maximum number of selected items per slice is set 100. Then individual networks are synthesized. The synthesized network covers 9042 references, 1584 nodes and 6324 connecting lines, with the density number 0.005 (Fig 9). Low density number indicates rather weak cooperation of the papers. The modularity (Q value) of the network is 0.7802, rather high, indicating that the segmentation of the research field into different modules through clustering is good, with clear community structure characteristics in the network. The silhouette score (S value) 0.8854 is also rather high, near to 1, meaning that most of the nodes are appropriately assigned to the appropriate clusters, with good clustering consistency. The harmonic mean (Q, S) is also rather high 0.8295. The clustering effect in this field is generally very good.

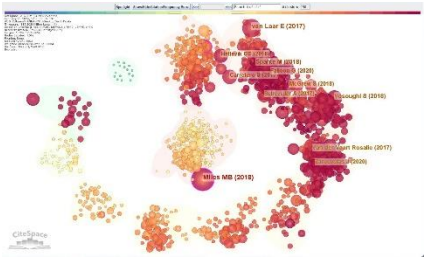

Figure 10. A visualization of top co-citation references (1992-2024)

As shown in Fig.9, a super-large node with purple ring stands out very prominently. To search out this prominent publication, another step was run by CiteSpace. This time the node type was chosen “terms and references”, timespan from 1992to 2024 with slice length equaling 1, and the co-cited references network graph was obtained (Fig.10). The mystery was solved and the answer revealed that it is Miles MB (2018). This is a co-work by Matthew B. Miles, A. Michael Huberman and Johnny Saldana. Their book, Qualitative Data Analysis: A Methods Sourcebook, is arguably one of the most important and widely known methodological reference books in the field of qualitative research (Miles et al., 2018). Till now, researchers need to think it over, and a confusion need to be solved—the book Qualitative Data Analysis: A Methods Sourcebook is most highly cited in the field of digital literacy (DL) research and is one of the most influential references in the field. This may seem surprising, since the book is not directly about DL. Such phenomenon reflects that although the subject of Miles et al. 's book is not digital literacy research per se, it serves as a key theoretical support and backbone for the development of the field at the methodological level. But some research methods have interdisciplinary value, can become important references in different fields, and promote the development of research practice. This also fully reflects the intersectional nature of scientific knowledge and the important role of good research methodological writings in advancing the disciplines.

Besides Miles et al. 's book, the other top 10 co-cited references, according to the frequency, are listed as follows: van Laar E (2017), Spante M (2018), van der Vaart Rosalie (Van Der Vaart & Drossaert, 2017), Vosoughi S (Vosoughi et al., 2018), Carretero S (Carretero et al., 2017), Mc Grew S (McGrew et al., 2018), Falloon G (2020), Hatlevik OE (Hatlevik et al., 2018), Scheerder A (Scheerder et al., 2017) and Zarocostas J (2020). The details are shown in Fig.11. In the list of these publications, the highest centrality is Miles MB’s, 0.16, higher than the medium level, indicating that the literature is in a relatively more important and central position in the knowledge network of its domain. Then van der Vaart Rosalie (Van Der Vaart & Drossaert, 2017) and Vosoughi S (Vosoughi et al., 2018) followed, with the centrality value 0.05 and 0.04 respectively. Fig. 14 and Fig 15 are corresponding to each other and show the top and important co-cited references in the research of DL.

Visible	Count	Central...	Year	Cited References
☑	121	0.16	2018	Miles MB, 2018, QUALITAT...
☑	77	0.03	2017	van Laar E, 2017, COMPU...
☑	72	0.01	2018	Spante M, 2018, COGENT ...
☑	60	0.05	2017	van der Vaart Rosalie, 201...
☑	56	0.04	2018	Vosoughi S, 2018, SCIEN...
☑	50	0.02	2017	Carretero S, 2017, DIGCO...
☑	49	0.02	2018	McGrew S, 2018, THEOR ...
☑	48	0.00	2020	Falloon G, 2020, ETR&D-...
☑	48	0.03	2018	Hatlevik OE, 2018, COMP...
☑	45	0.02	2020	Zarocostas J, 2020, LANC...
☑	45	0.03	2017	Scheerder A, 2017, TELE...
☑	44	0.06	2018	Porat E, 2018, COMPUT E...
☑	44	0.00	2018	Tricco AC, 2018, ANN INT...
☑	44	0.01	2018	Kayser L, 2018, J MED INT...
☑	43	0.01	2021	Dadaczynski K, 2021, J M...
☑	43	0.02	2019	Giles P, 2019, J CULT EC...
☑	43	0.02	2016	Pangrazio L, 2016, DISCO...
☑	42	0.03	2017	Allcott H, 2017, J ECON P...
☑	41	0.01	2020	Reddy P, 2020, INT J TEC...
☑	41	0.01	2019	Hair JF, 2019, EUR BUS R...
☑	39	0.01	2019	van Deursen AJAM, 2019, ...
☑	39	0.02	2010	Kress G, 2010, MULTIMO...
☑	38	0.01	2019	Hargittai E, 2019, UNIVER...
☑	37	0.00	2020	Paakkari L, 2020, LANCET...
☑	37	0.01	2018	Lazer DMJ, 2018, SCIENC...
☑	37	0.03	2019	Pangrazio L, 2019, NEW M...
☑	37	0.01	2018	Hunsaker A, 2018, NEW M...
☑	36	0.02	2020	Jin KY, 2020, COMPUT ED...
☑	35	0.03	2016	Saldana J, 2016, THE CO...
☑	34	0.01	2013	Leu D, 2013, THEORETIC...
☑	34	0.01	2021	Jones RH, 2021, UNDER...
☑	34	0.10	2014	Coiro J, 2014, HANDBOO...
☑	34	0.00	2021	Page MJ, 2021, BMJ-BRIT ...
☑	34	0.03	2018	Gudmundsdottir GB, 2018...
☑	33	0.02	2016	Friemel TN, 2016, NEW M...
☑	32	0.02	2017	Kim H, 2017, PATIENT ED...
☑	32	0.09	2014	van Deursen AJAM, 2014, ...
☑	32	0.02	2018	Pettersson F, 2018, EDUC...
☑	32	0.01	2018	R Core Team, 2018, R: A ...
☑	32	0.00	2018	Anderson M, 2018, TEENS...
☑	31	0.00	2021	Jones-Jang SM, 2021, AM ...
☑	31	0.01	2020	Guess AM, 2020, P NATL ...
☑	31	0.00	2020	Hodges C, 2020, EDUCA...
☑	30	0.03	2015	Leu DJ, 2015, READ RES ...
☑	30	0.04	2017	Creswell JW, 2017, DESI...
☑	30	0.00	2020	Okan O, 2020, INT J ENV ...
☑	30	0.00	2019	Pennycook G, 2019, COG...
☑	29	0.01	2020	Beaunoyer E, 2020, COMP...
☑	29	0.00	2019	Guess A, 2019, SCI ADV, ...
☑	29	0.00	2010	National Governors Assoc...
☑	29	0.00	2018	Tandoc EC, 2018, DIGIT J...
☑	29	0.00	2014	Vitak J, 2014, J BROADCA...
☑	28	0.00	2015	Takacs ZK, 2015, REV ED...
☑	28	0.00	2018	Ozili PK, 2018, BORSA IST...
☑	28	0.00	2020	Hafner CA, 2020, J SECO...

Figure 11. A list of top co-citation references (1992-2024)

Conclusion and Limitations

This paper shows an overall view of the global research in DL and explore the overall trends in publication and citations in DL research. This study systematically examined the countries distribution, institutions distribution, journals distribution and cited authors distribution. With CiteSpace, this paper conducted the keywords co-occurrence analysis,

reference co-citation analysis, term and cited references analysis, showing the science mapping and timeline view, etc. to generate a variety of visualizations and map the knowledge structure of the research in DL, and to explore the research frontiers or emerging trends of DL research.

A visual analysis of country collaboration showed that 129 countries have been engaged in and conducted the research in DL, and the United States ranked as the first not only in terms with publications and citations, but also with the centrality value. In relation to constitutional contributions, the top 12 institutions contributed the most papers. The University of London is ranked first, the University of California System is the second, followed by another famous university Harvard University. The top 3 cited journals are Computers & Education (from UK), Journal of Medical Internet Research (from Canada) and Computers in Human Behavior (from UK). Among the top 10 cited journals, 4 journals are from England, 1 from USA, 1 Canada, 3 Switzerland and 1 Netherlands. These high frequently cited journals also explain why the highest centrality of all countries doing the research in DL are UK and USA, and England is even higher than USA, ranking top in the list of countries.

In order to better understand the emerging trends and research frontier of DL, burst detection of keywords and cited references were examined. In the mapping of top 25 keywords with the strongest citation bursts, these 25 keywords can be regarded as the hot issues of DL. New literacies has the highest strength value 51.65, then media literacies (strength value 45.24) follows, and then digital divide (strength value 34.98) and early adolescence (strength value 31.65). When the strength value exceeded 30, it indicates that these keywords had very high significant strength and importance during their citation burst outburst, and could be regarded as the absolute core hot topics in this stage. In particular, the key word whose strength is as high as 51.65 can be regarded as the undoubtedly dominant research topic in this stage, and the hottest and core focus of academic discussion. These four sets of keywords could be taken as the absolute core during their periods.

From the steady increase of DL from scratch three decades ago to steady increase in the past ten years, especially the sharp increase in publications in the last five years, all indicates that this field is an emerging field and has become a hot topic for researchers in recent years. But there have been very few aritcles using scientometric analysis, with a visual analytic tool CiteSpaceand knowledge network visualization for analyzing trends and patterns in the scholarly literature of DL. Or some articles are covering shorter span of time, ten years or less than ten years. There is still great room for development in this field. To the best of our knowledge, this study would be the first comprehensive and exhaustive scientometric analysis, which covers all literatures in DL from the very beginning to the date this study was carried out (1990 to 2024), and this study can offer basic and important support, provide constructional guidance for researchers and educators in the future.

The study is not without limitations. First, as we have discussed earlier, although a variety of tools are available to perform scientometric analysis, CiteSpace was employed in this study to examine the overall trends and the research frontiers of DL. Other analyzing tools may lead to different processes and results. Second, when predicting the underlying trends, some deviations may be inevitable. In addition, this study is to study DL from the initial origin to the latest period, hoping to cover the literature from WoS core collection, but there may be omissions. Future studies could solve these limitations to validate the findings.

Data Availability: Data will be made available upon request.

Conflict of Interest: There is no conflict of interest for any of the participants.

References

Ahmadvand, A., Kavanagh, D., Clark, M., Drennan, J., & Nissen, L. (2019). Trends and visibility of “digital health” as a keyword in articles by JMIR publications in the new millennium: Bibliographic-bibliometric analysis. Journal of medical Internet research, 21(12), e10477.

Audrin, C., & Audrin, B. (2022). Key factors in digital literacy in learning and education: a systematic literature review using text mining. Education and information technologies, 27(6), 7395-7419.

Ba, H., Tally, W., & Tsikalas, K. (2002). Investigating children's emerging digital literacies. The Journal of Technology, Learning and Assessment, 1(4).

Bawden, D. (2008). Origins and concepts of digital literacy. Digital literacies: Concepts, policies and practices, 30(2008), 17-32.

Bennett, S., Maton, K., & Kervin, L. (2008). The 'digital natives' debate: A critical review of the evidence. British journal of educational technology, 39(5), 775-786.

Buchholz, B. A., DeHart, J., & Moorman, G. (2020). Digital citizenship during a global pandemic: Moving beyond digital literacy. Journal of Adolescent & Adult Literacy, 64(1), 11-17.

Carretero, S., Vuorikari, R., & Punie, Y. (2017). DigComp 2.1: The digital competence framework for citizens.

Chen, C. (2006). CiteSpaceII: Detecting and visualizing emerging trends and transient patterns in scientific literature. Journal of the American Society for information Science and Technology, 57(3), 359-377.

Chen, C. (2017). Science mapping: a systematic review of the literature. Journal of data and information science, 2(2), 1-40.

Chen, C., & Song, M. (2019). Visualizing a field of research: A methodology of systematic scientometric reviews. PloS one, 14(10), e0223994.

Coiro, J. (2003). Exploring literacy on the Internet. The reading teacher, 56(5), 458-464.

Coiro, J., Knobel, M., Lankshear, C., & Leu, D. J. (2014a). Central issues in new literacies and new literacies research. In Handbook of research on new literacies (pp. 1-22). Routledge.

Coiro, J., Knobel, M., Lankshear, C., & Leu, D. J. (2014b). Handbook of research on new literacies. Routledge.

Collins, J. (1995). Literacy and literacies. Annual review of anthropology, 24(1), 75-93.

Cope, B., & Kalantzis, M. (2009). Ubiquitous learning. University of Illinois press.

Danni, C., Qi, Z., Jiahui, Q., Liang, C., & Zhonglu, G. (2018). Literature review on the role of root in soil erosion control based on the knowledge map. Sci. Soil Water Conserv, 16, 124-135.

Eshet, Y. (2004). Digital literacy: A conceptual framework for survival skills in the digital era. Journal of educational multimedia and hypermedia, 13(1), 93-106.

Falloon, G. (2020). From digital literacy to digital competence: the teacher digital competency (TDC) framework. Educational Technology Research and Development, 68, 2449-2472

Gee, J. (1991). Socio-cultural approaches to literacy (literacies). Annual review of applied linguistics, 12, 31-48.

Gilster, P., & Glister, P. (1997). Digital literacy. Wiley Computer Pub. New York.

Guo, Y., Hao, Z., Zhao, S., Gong, J., & Yang, F. (2020). Artificial intelligence in health care: bibliometric analysis. Journal of medical Internet research, 22(7), e18228.

Hatlevik, O. E., Throndsen, I., Loi, M., & Gudmundsdottir, G. B. (2018). Students' ICT self-efficacy and computer and information literacy: Determinants and relationships. Computers & Education, 118, 107-119.

Hiebert, E. H. (2002). Standards, assessment, and text difficulty. What research has to say about reading instruction, 3, 337-369.

Huang, H., Jian, M., & Wu, X. (2023). Research hotspots and development trends of international learning cycle model: Bibliometric analysis based on CiteSpace. Heliyon.

Jam, F. A., Khan, T. I., & Paul, J. (2025). Driving brand evangelism by Unleashing the power of branding and sales management practices. Journal of Business Research, 190, 115214.

Jam, F. A., Singh, S. K. G., Ng, B., & Aziz, N. (2016). Effects of Uncertainty Avoidance on Leadership Styles in Malaysian Culture, , International Journal of Advance Business and Economics Research, 14(8), 7029-7045.

Januszewski, A., & Molenda, M. X. (2013). Educational technology: A definition with commentary. Routledge.

Jewitt, C., & Kress, G. (2010). Multimodality, literacy and school English. In The Routledge international handbook of English, language and literacy teaching (pp. 342-352). Routledge.

Knobel, M., & Lankshear, C. (2004). Planning pedagogy for i-mode: from flogging to blogging via wi-fi. English in Australia (139), 78-102.

Lankshear, C., & Knobel, M. (2011). New literacies: Everyday practices and social learning. McGraw-Hill Education (UK).

Lee, C. D. (1992). Literacy, cultural diversiiy, and instruction. Education and Urban Society, 24(2), 279-291.

Lee, T., Lee, B.-K., & Lee-Geiller, S. (2020). The effects of information literacy on trust in government websites: Evidence from an online experiment. International Journal of Information Management, 52, 102098.

Leu, D. J., Coiro, J., Castek, J., Hartman, D. K., Henry, L. A., & Reinking, D. (2008). Research on instruction and assessment in the new literacies of online reading comprehension. Comprehension instruction: Research-based best practices, 2, 321-346.

Leu, D. J., Forzani, E., Burlingame, C., Kulikowich, J., Sedransk, N., Coiro, J., & Kennedy, C. (2013). The new literacies of online research and comprehension: Assessing and preparing students for the 21st century with Common Core State Standards. Quality reading instruction in the age of Common Core Standards, 219, 236.

Leu, D. J., Forzani, E., Rhoads, C., Maykel, C., Kennedy, C., & Timbrell, N. (2015). The new literacies of online research and comprehension: Rethinking the reading achievement gap. Reading Research Quarterly, 50(1), 37-59.

Li, M., & Yu, Z. (2022). Teachers' satisfaction, role, and digital literacy during the COVID-19 pandemic. Sustainability, 14(3), 1121.obal Parkinson's disease research trends during 1991–2006. Neuroscience letters, 441(3), 248-252.

Liu, Z.-J., Tretyakova, N., Fedorov, V., & Kharakhordina, M. (2020). Digital literacy and digital didactics as the basis for new learning models development. International Journal of Emerging Technologies in Learning (iJET), 15(14), 4-18.

Marín, V. I., & Castaneda, L. (2023). Developing digital literacy for teaching and learning. In Handbook of open, distance and digital education (pp. 1089-1108). Springer.

Martin, A. (2008). Digital literacy and the "digital society". Digital literacies: Concepts, policies and practices, 30(2008), 151-176.

Martin, A., & Grudziecki, J. (2006). DigEuLit: Concepts and tools for digital literacy development. Innovation in teaching and learning in information and computer sciences, 5(4), 249-267.

Martins Van Jaarsveld, G. (2020). The effects of COVID-19 among the elderly population: a case for closing the digital divide. Frontiers in psychiatry, 11, 577427.

McGrew, S., Breakstone, J., Ortega, T., Smith, M., & Wineburg, S. (2018). Can students evaluate online sources? Learning from assessments of civic online reasoning. Theory & research in social education, 46(2), 165-193.

Miles, M. B., Huberman, A. M., & Saldana, J. (2018). Qualitative data analysis: A methods sourcebook. In (pp. 116-148). In: United States of America: Sage Publications.

NS, Prema, Shashikala BM, and Chaithra KG. "Predictive Modeling of Water Quality Index (WQI) Using Regression Techniques: A Comparative Analysis." آب مهندسی و زیست محیط (2025).

Oh, S. S., Kim, K.-A., Kim, M., Oh, J., Chu, S. H., & Choi, J. (2021). Measurement of digital literacy among older adults: systematic review. Journal of medical Internet research, 23(2), e26145.

Pangrazio, L. (2016). Reconceptualising critical digital literacy. Discourse: Studies in the cultural politics of education, 37(2), 163-174.

Park, H., Kim, H. S., & Park, H. W. (2020). A scientometric study of digital literacy, ICT literacy, information literacy, and media literacy. Journal of Data and Information Science, 6(2), 116-138.

Pettersson, F. (2020). Understanding digitalization and educational change in school by means of activity theory and the levels of learning concept. Education and Information Technologies, 26(1), 187-204.

Prensky, M. (2001). Digital natives, digital immigrants part 2: Do they really think differently? On the horizon, 9(6), 1-6.

Pritchard, A. (1969). Statistical bibliography or bibliometrics. Journal of documentation, 25, 348.

Purnama, S., Ulfah, M., Machali, I., Wibowo, A., & Narmaditya, B. S. (2021). Does digital literacy influence students' online risk? Evidence from Covid-19. Heliyon, 7(6).

Sá, M. J., Santos, A. I., Serpa, S., & Ferreira, C. M. (2021). Digital Literacy in Digital Society 5.0. Academic Journal of Interdisciplinary Studies, 10(2), 1-9.

Scheerder, A., Van Deursen, A., & Van Dijk, J. (2017).

Determinants of Internet skills, uses and outcomes. A systematic review of the second- and third-level digital divide. Telematics and informatics, 34(8), 1607-1624.

Spante, M., Hashemi, S. S., Lundin, M., & Algers, A. (2018). Digital competence and digital literacy in higher education research: Systematic review of concept use. Cogent Education, 5(1), 1519143.

Stopar, K., & Bartol, T. (2019). Digital competences, computer skills and information literacy in secondary education: mapping and visualization of trends and concepts. Scientometrics, 118(2), 479-498.

Tian, X., & Park, K. H. (2023). Visualizing the Research Development and Hotspots in Digital Literacy. Advance.

United Nations Educational, Scientific and Cultural Organization (UNESCO). (2018). A Global Framework of Reference on Digital Literacy Skills for Indicator 4.4.2. Retrieved March 4, 2024, from https://uis.unesco.org/sites/default/files/documents/ip51-global-framework-reference-digital-literacy-skills-2018-en.pdf

United Nations. (2015). Transforming Our World: The 2030 Agenda for Sustainable Development. Retrieved March 4, 2024, from https://sustainabledevelopment.un.org/post2015/transformingourworld/publication

Valverde-Berrocoso, J., Garrido-Arroyo, M. d. C., Burgos-Videla, C., & Morales-Cevallos, M. B. (2020). Trends in educational research about e-learning: A systematic literature review (2009–2018). Sustainability, 12(12), 5153.

Van Der Vaart, R., & Drossaert, C. (2017). Development of the digital health literacy instrument: measuring a broad spectrum of health 1.0 and health 2.0 skills. Journal of medical Internet research, 19(1), e27.

Van Laar, E., Van Deursen, A. J. A. M., Van Dijk, J. A. G. M., & De Haan, J. (2017). The relation between 21st-century skills and digital skills: A systematic literature review. Computers in Human Behavior, 72, 577-588.

Veronika, R., Camelia, C., Febriliana, R., & Yapen, Y. E. (2023). DIGITAL LITERACY AS A SOCIAL MOBILIZATION AND LEARNING PLATFORM. SEIKAT: Jurnal Ilmu Sosial, Politik dan Hukum, 2(3), 228-241.

Vosoughi, S., Roy, D., & Aral, S. (2018). The spread of true and false news online. science, 359(6380), 1146-1151.

Wang, C., & Si, L. (2023). A Bibliometric Analysis of Digital Literacy Research from 1990 to 2022 and Research on Emerging Themes during the COVID-19 Pandemic. Sustainability, 15(7), 5769.

Yang, J., Qi, H., Li, A., Liu, X., Yang, X., Zhang, S., . . . Zhang, L. (2022). Potential-driven restructuring of Cu single atoms to nanoparticles for boosting the electrochemical reduction of nitrate to ammonia. Journal of the American Chemical Society, 144(27), 12062-12071.

Yang, K., Hu, Y., & Qi, H. (2022). Digital health literacy: bibliometric analysis. Journal of medical Internet research, 24(7), e35816.

Yeşilyurt, E., & Vezne, R. (2023). Digital literacy, technological literacy, and internet literacy as predictors of attitude toward applying computer-supported education. Education and information technologies, 1-27.

Zarocostas, J. (2020). How to fight an infodemic. The lancet, 395(10225), 676.

Zhang, L., Lin, Y., Zhou, S., & Qin, Q. (2024). Evolution and trends of new energy vehicle policy research hotspots: an analysis based on a CiteSpaceknowledge graph. Environmental Science and Pollution Research, 31(5), 7728-7750.