

## A Bibliometric Analysis on Research Trends of Digital Literacy in Higher Education from 2012 to 2021

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**Abstract**—Digital literacy is a multidimensional concept that encompasses a complex integration of knowledge, skills, attitudes, and cognition dimensions, which gains increased attention in the context of higher education. The objective of this study is to analyze the scientific production of digital literacy in higher education from 2012 to 2021 based on the Scopus database, and reveal the current research trends on this subject. To this end, a bibliometric study was carried out, which first investigated some variables that addressed different features, from the distribution of publications to the most productive countries/regions and the prolific publication venues, and continued with the analysis of the authors and the keywords co-occurrence through VOSviewer software. The results show that the most frequently explored themes in the area of digital literacy can be detected, which focused on the integration of digital technology, ontology research and the educational practices of digital literacy, and the effectiveness evaluation of digital literacy in the time of the COVID-19 pandemic. The findings of this study are beneficial for researchers to gain a comprehensive understanding of digital literacy in the domain of higher education, and provide new directions for future research.

**Keywords**—digital literacy, higher education, bibliometric analysis

### 1 Introduction

Digital technologies are increasingly being used in educational praxis across the globe [1]. Mobile devices, Wiki platforms, social media, and video gaming are gradually becoming popular among higher education institutions. This trend is transforming the ways of teaching and learning at the tertiary level [2], which raises researchers' growing interest to explore the topic of digital literacy in today's higher education settings.

In literacy studies, digital literacy could date back to 1960, and the origins of the contemporary understanding of the term were introduced and made known in the sense by the work of Gilster in 1997 [3]. Since then, it has evolved with time due to the fact that the technological, social and cultural stance redefined the usage of digital technology in life and work [4]. Generally, digital literacy is referred to as a multidimensional

concept that encompasses a complex integration of knowledge, skills, attitudes and cognition necessary for the confident, creative and critical use of technologies and systems [5]. It indicates that the scope of digital literacy relates to many aspects of life, and involves the mastery of ideas rather than mere know-how and technical skills [6]. In other words, the conceptual understanding of digital literacy varies depending on the scientific perspective and ideological viewpoints involved, which generated many variations such as media literacy, information literacy and digital competence.

Given its significance in digitalized society, publications linking with digital literacy have led to theoretical and practical discussions. Many studies have been carried out on either macro-level investigations and systematic literature reviews of digital literacy or micro-level analyses of digital literacy assessment and training for individuals [7, 8]. For example, Stopar and Bartol [9] conducted a review of digital-related literacy in the scope of secondary education, pointing out that different research narratives should be involved in a collaborative way. At the micro level, Cabero-Almenara et al. [10] investigated the digital competence of higher education teachers from the perspectives of knowledge field and age range, and further proposed possible solutions for improving the digital training of teaching staff. Similar studies have been performed to delve into digital literacy of learners. Mehrvarz et al. [11] explored the role of digital literacy between university students' digital learning and their perceived academic performance, which emphasized the essential role of digital competence and technology adoption in digital informal learning [12]. In addition, with the outbreak of the COVID-19 health crisis, the concern about digital literacy reached a new height as traditional classroom teaching activities were suspended [13]. The focus on digital literacy has gained increasing attention as it supported the functioning of higher educational institutions in the unprecedented difficult times [4]. The pandemic forced learners to take a digital leap in learning modes and initiated an extensive and dramatic digital transformation in society [14].

Although prior studies were performed on the related issues of digital literacy [15, 16], there have been very few attempts to systematically review the scientific publication of digital literacy in higher education by using the bibliometric method. As such, to address this subject, we seek to review the development of digital literacy research at the higher education level from 2012 to 2021, aiming to assess the state of the art in digital literacy, and reveal the panorama of global digital literacy through performance analysis and science mapping. Therefore, the present study focuses on four research questions as follows:

1. What is the general publication trend in the area of digital literacy?
2. Which countries/regions, funding sponsors, publication venues and authors have been most impactful in the area of digital literacy?
3. What are the most frequently used keywords related to digital literacy?
4. What are the important research themes in the area of digital literacy?

## 2 Methods

Bibliometric analysis was adopted in this study, and the procedures for data collection and processing were described. Bibliometrics is considered as a statistical method used to handle scientific data, unpack knowledge development, identify research impact, decipher discipline nuances, and uncover research topics [17]. So this method can offer an objective and quantitative analysis for the measurement of the contribution of academic output to the advancement of knowledge within a specific subject [18].

For the proposed questions, the bibliometric information of publications was retrieved from the Scopus database, a prestigious data source for its delivery of global research output. The retrieved publications from the database could be exported to a visualized software tool for further analysis. To ensure the validity and reliability of the data collection, a rigorous process of review of the literature was applied. First, the formulation of the search strategy was given special attention to limit the queries to a few choice phrases. Considering the importance of using synonyms in the search string, the search statement with consideration of similar terms and different spellings was defined as follows: TITLE-ABS-KEY (“digital literac\*” OR “digital technolog\*” OR “digital competenc\*” OR “digital skill\*”) AND (“higher education” OR “universit\*” OR “college\*”). Altogether, we tested four digital-related terms in relation to three educational terms on January 28, 2022. Second, the starting year of the queries was set from January 2012 to December 2021 as this study aimed to explore the emerging trends of digital literacy in recent 10 years. Furthermore, all publications were limited to the document type of “article” published in English. As shown in Table 1, the inclusion and exclusion criteria were established to exclude the irrelevant records [19]. As a result, the final sample of 1832 items with all bibliometric information available in the Scopus database was exported in CVS format after a careful manual check.

**Table 1.** Inclusion criteria and exclusion criteria

Inclusion criteria	Exclusion criteria
Studies are pertinent to digital literacy in higher education settings.	Studies do not address digital literacy in higher education settings.
Types of publications are articles except articles in press.	Conference paper, review, editorial material and note.
The time span is from 2012 to 2021.	The time span is earlier than 2012 and later than 2021.
Research articles are written in English.	Research articles are written in other languages.
The full version of the publication is available through the subscription of our institution.	The full version of the publication is unavailable.

With regard to research instruments, Microsoft Excel and VOSviewer (version 1.6.17) were applied to make quantitative analysis and data visualization. Excel was employed to manage the bibliographic records and generate visualized diagrams. As a free Java-based computer program designed by Eck and Waltman, VOSviewer mainly focuses on the visualization and trend detection of scientific publications [20]. It was

adopted to compute the co-authorship relations and the co-occurrence network of keywords and produce the bibliometric maps of science. Finally, both text data and bibliographic data were analyzed, synthesized and visualized in corresponding diagrams [21].

### 3 Results

In this section, we present the results of the study through the analysis of the data collected, which is structured according to the questions posed above.

#### 3.1 Annual distribution of publications

The annual number of publications pertinent to digital literacy is presented in Figure 1. The results show how the number of articles has been distributed in the examined period. Despite the slight fluctuation in the years of 2013 and 2015, the total production has continued to be on the rise during the past decades. Starting from 2018 which saw 173 articles published, annual publications increased rapidly. It is notable that the year of 2021 with 480 articles accounts for 26.20% of the total production, which may indicate increasing attention in this field. That is, digital literacy research has become a hot topic since 2018, which kept abreast of emerging developments in digital teaching and learning environment. As is evident from the diachronic productivity, a growing trend seems to continue in the coming years.

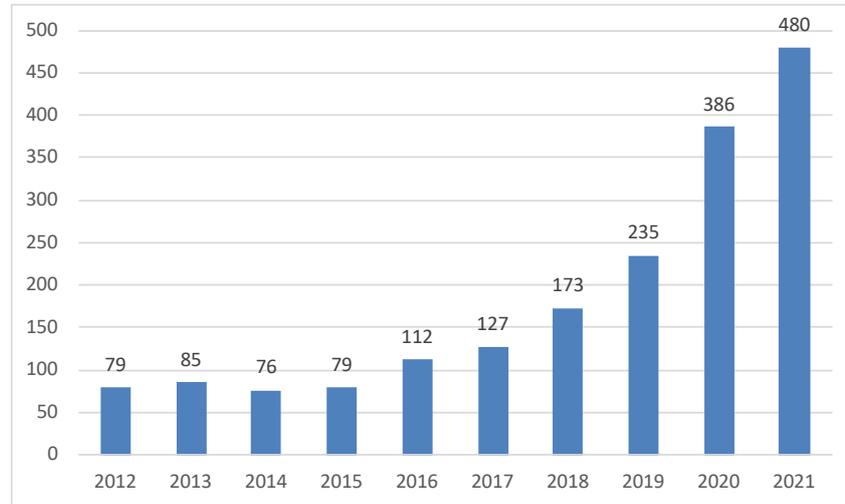


Fig. 1. Annual publications of digital literacy (2012-2021)

#### 3.2 Geographical distribution and funding sponsors

The results illustrate that 95 countries/regions made contributions to digital literacy research. The most productive countries/regions are displayed in Table 2. European

countries published the largest number of publications (33.18%), followed by North American (18.44%), Asian (8.62%), and Oceanian (8.24%) countries. In terms of prolific countries, the United States took a leading role with 280 articles, and the United Kingdom (223), Spain (201), Australia (151) and Russian Federation (132) followed behind. In addition, 3 out of the top 10 countries are from Asia, which published around 150 articles in total, and the outputs accounted for 8.13% of all publications during the examined period [22].

**Table 2.** Top 10 productive countries/regions (2012-2021)

Rank	Countries/regions	Publications	Percentage
1	United States	280	15.283
2	United Kingdom	223	12.172
3	Spain	201	10.971
4	Australia	151	8.242
5	Russian Federation	132	7.205
6	Canada	58	3.165
7	India	52	3.327
8	Italy	52	2.838
9	Mainland China	50	2.729
10	Indonesia	47	2.565

Besides, taking into account the funding sponsors, the top 10 funding sponsors are illustrated in Figure 2. European and American institutions have most contributed to digital literacy research, especially European Commission (n=23), Economic and Social Research Council (n=16), and European Regional Development Fund (n=15). The generous funding supports from European countries indicated an agreement with a large number of scientific publications in this region. For example, as the leading research funding organization in the United Kingdom, the Economic and Social Research Council has been dedicated to supporting academic research on various social issues. So it can be seen that funding from governments or institutions is a beneficial support to motivate more researchers to participate in scientific publication and boost research productivity [23].

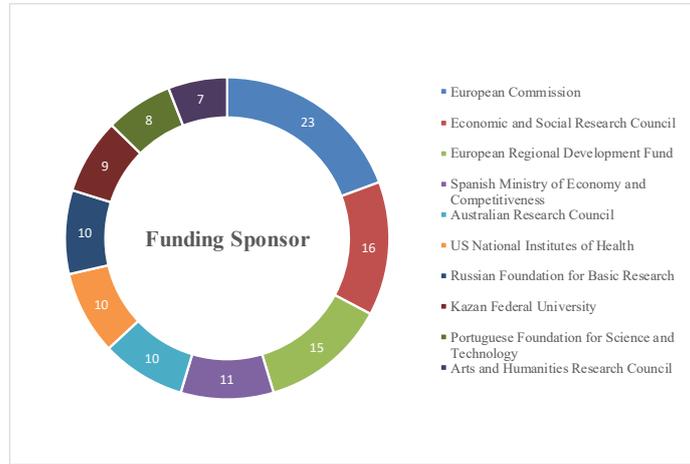


Fig. 2. Top 10 funding sponsors (2012-2021)

### 3.3 Publication venues and subject categories

According to the journal quartile in the SCImago Journal Rank (SJR) 2020 ranking, the top 10 publication venues with the number of publications and the impact factor are listed in Table 3. These journals contributed 261 publications, making up 14.24% of total output. Three journals with the highest number of published articles in the field are Sustainability Switzerland (47 articles), Education Sciences (34), and Library Philosophy and Practice (34). It was noteworthy that as an interdisciplinary journal in the post-secondary field, the International Journal of Emerging Technologies in Learning published 30 articles concerning digital literacy across the examined years. On the whole, the results indicate that the publication venues related to the domains of educational technology and computer science have concentrated the most on digital literacy research.

Table 3. Top 10 publication venues (2012-2021)

Rank	Publication venues /Journals	Publications	Percentage	Factor of Impact
1	Sustainability Switzerland	47	2.565	0.612
2	Education Sciences	34	1.855	0.453
3	Library Philosophy and Practice	34	1.855	0.233
4	International Journal of Emerging Technologies in Learning	30	1.637	0.454
5	Nordic Journal of Digital Literacy	27	1.473	0.465
6	Education and Information Technologies	22	1.201	0.919
7	International Journal of Educational Technology in Higher Education	18	0.982	1.642
8	Australasian Journal of Educational Technology	17	0.927	1.397
9	Computers and Education	16	0.873	3.026
10	Research in Learning Technology	16	0.873	0.520

Furthermore, as the scientific publications were distributed in an array of categories, the top 10 subject categories are illustrated in Figure 3. Publications involved in the fields of computer science and arts and humanities are the principal contributors. More specifically, computer science (480, 26.20%) was the most common category, while arts and humanities (264, 14.41%), engineering (183, 9.98%), psychology (140, 7.64%), business, management and accounting (123, 6.71%) followed behind. Among them, it is observed that mathematics (46, 2.51%) is the least field of publication [24].

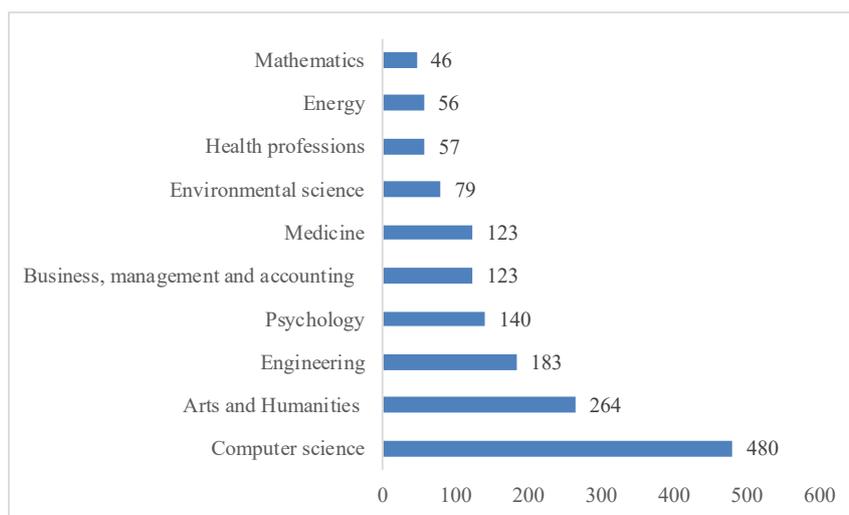


Fig. 3. Top 10 subject categories (2012-2021)

### 3.4 Authors

Totally 5,158 authors participated in the research of digital literacy. As indicated in Table 4, 10 productive authors who published more than 4 articles in this area are presented, of which 6 (60%) are from Spanish affiliations. Among them, Guillén-Gámez topped the ranking list with 8 articles, and most of his articles concentrated on examining the digital competence of higher education faculties since the topics he contributed most were technology integration and technology acceptance model [25, 26]. What's more, authors from other countries are also prolific. For instance, Akhmetshin, who occupied the third place with 7 articles, specialized in peculiarities analysis of digital technologies as well as digital transformation of education and universities [27]. Blay-one ranked sixth with 5 publications on digitalized learning readiness of university students and teachers, proposing that digital competency development should become an education priority [28, 29].

**Table 4.** Top 10 productive authors with more than 4 publications (2012-2021)

Rank	Authors	Affiliations	Publications
1	Guillén-Gámez, F. D.	University of Cordoba, Spain	8
2	Palacios-Rodríguez, A.	University of Sevilla, Spain	8
3	Akhmetshin, E. M.	Kazan Federal University, Russia	7
4	Selwyn, N.	Monash University, Australia	7
5	Mayorga-Fernández, M. J.	University of Malaga, Spain	6
6	Blayone, T. J. B.	University of Ontario Institute of Technology, Canada	5
7	Cabero-Almenara, J.	University of Sevilla, Spain	5
8	Gómez-Trigueros, I. M.	University of Alicante, Spain	5
9	Ameen, K.	University of Home Economics, Pakistan	4
10	Barroso-Osuna, J.	University of Seville, Spain	4

Moreover, the network made of co-authorship relations produced by VOSviewer is presented in Figure 4. We set the minimum number of documents of per author to 3, and a total of 63 authors met the threshold. The results show that in the network map there are 10 nodes with 38 links, which were assigned to 3 clusters. Each node refers to an independent author. The link between a pair of nodes indicates a co-authorship relationship, and its thickness is weighted by the number of co-authored documents [30]. In other words, the stronger the link between two nodes is, the thicker the line used to display the link is. What's more, different cluster colors indicate different groups of authors. For example, the red cluster was constructed by five authors who have a much closer relatedness compared with authors in other clusters. Likewise, the blue cluster took Guillén-Gámez as the center point with 5 co-authors. His closest collaborator was Mayorga-Fernández in the area of digital literacy research due to the thickness of the link between the two nodes (Link strength=5). Most of Guillén-Gámez's publications had Mayorga-Fernández as co-author due to their similar interests in the variable analysis and evaluation of higher education teachers' digital competence [25, 31]. Furthermore, 5 out of the most prolific authors were included in the network map, which implied co-authorship is a contributing factor to boosting publication productivity.

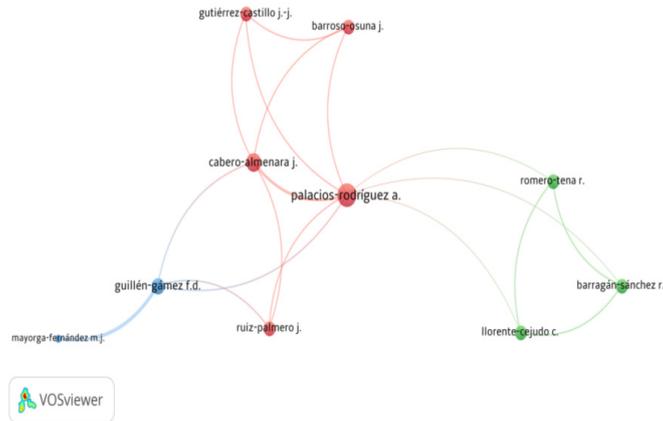


Fig. 4. The co-authorship network map of authors

### 3.5 Keywords

As an important component, keywords can effectively reflect the core idea of research articles, which proved to be vital for decoding the themes of a specific discipline field to some extent [32]. The keyword co-occurrence network map of digital literacy generated by VOSviewer is shown in Figure 5. Keywords provided by authors of the publications were employed in the final analysis. The minimum number of occurrences of author keywords was set as 36, and 50 most frequently used author keywords were selected. As the visual map indicates, the size of the nodes refers to the frequency of occurrence. The bigger the node is, the higher the occurrence is, and vice versa [33]. The nodes and labels for digital technology, practice and teacher are the largest in the co-occurrence network of author keywords. To be specific, the keywords that appeared most were “digital technology” (868 occurrences), “practice” (472), “teacher” (424), “information literacy” (398), “digital literacy” (330), “system” (275), “training” (262), “questionnaire” (259) and “implication” (204).

In addition, the link strength of a pair of nodes represents the frequency of co-occurrence between nodes [33]. For example, the node “digital technology” has the thicker links with the node “practice”, “interaction” and “strategy” among its 49 links, which indicates that these keywords appeared together in the same publication. Meanwhile, as the nodes with the same color belong to a cluster, the network map shows these clusters of nodes are the most frequent keywords that occurred in scientific publications of digital literacy. It is apparent that these keywords could be grouped into 4 thematic clusters, consisting of digital technology (green), digital literacy (red), digital competence (blue), and COVID-19 pandemic (yellow). The observations from the network manifest that the clusters of keywords related to many relevant terms, which mainly include the innovation of digital technology, the implication of digital literacy, the training of teachers’ digital competence, and the effectiveness of digital literacy during the time of COVID-19 pandemic.

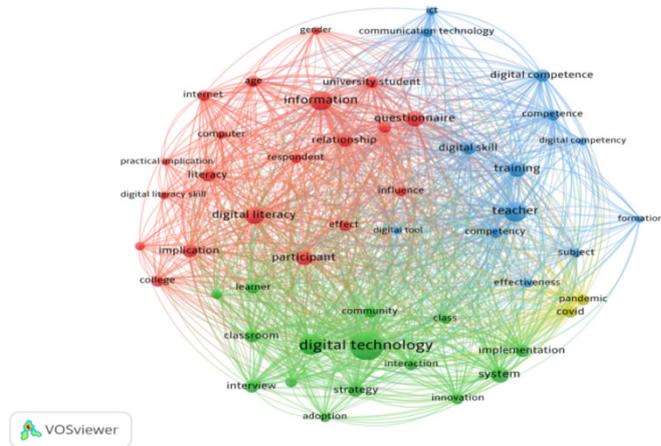


Fig. 5. The co-occurrence network of top 50 author keywords

Concerning keyword trends, Figure 6 shows the overlay visualization of the distribution of author keywords according to keyword co-occurrence by year. Prevailing concepts of the network map in a given average time period were labeled by different colors. The keywords with the deeper purple mean they appeared earlier [34], while the keywords with the brighter yellow indicate they appeared later. It can be found that the articles published in recent 3 years mainly centered on “effectiveness” (avg. pub. year=2019.02, occurrence=98), “digital competence” (2019.80, 76) and the relationship between digital literacy and “COVID” (2020.80, 163), “pandemic” (2020.81, 141).

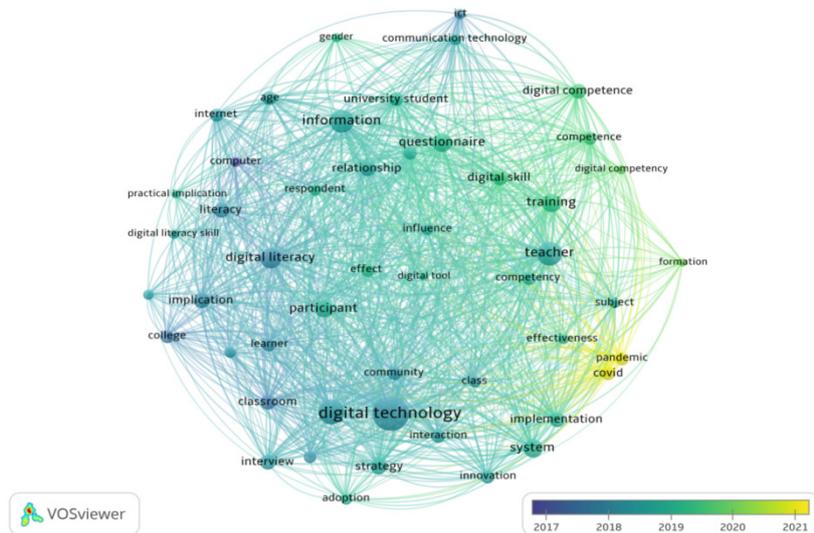


Fig. 6. Distribution of top 50 frequently used author keywords by year

## 4 Discussion

From the present study, a total of 1832 publications concerning digital literacy indexed in the Scopus database were analyzed. The bibliometric profile of scientific publications provided a comprehensive overview of research progress and detected emerging trends in digital literacy research. Combined with the network analysis of keyword co-occurrence, the most frequently explored research themes could be identified as follows:

**Integration of digital technology.** Technology integration in the area of digital literacy could fall into 3 broad types, which cover the application of digital technology, the adoption of digital devices for teaching and learning, and the construction of technology-supported digital learning systems [2]. For one thing, with the progress of new technology, digital learners have been provided ample opportunities for the increasing use of technology. Meanwhile, higher education institutions have made effective use of advances in digital technology to engage teachers and learners with different modes, which spurred the integration of new technology with the learning delivery process. For another, the affordance of digital technology was an effective impulse toward the establishment of digital teaching and learning environments. In particular, the expansion of technology-aided management systems was given special attention, such as E-learning systems and M-learning systems [35]. Thus, practices and innovations in digital technology paved the way for the continuous development of digital literacy research.

**Ontology research of digital literacy.** As digital literacy is generally considered as an evolving and dynamic notion, its conceptualization has been in an expanding state with the advancement of cognitive ability and social practices as well as the evolving new technologies. So prior studies were conducted on the ontology research of digital literacy [5], which focused on its connotations and the related variations of the term (e.g. computer literacy, information literacy, and media literacy). As it were, the definition of digital literacy has undergone a series of practical discussions from the previous monolithic construct to the plurality of proficiencies [7]. The current research is more inclined to acknowledge the plurality of viewpoints, approaching digital literacy from different perspectives such as the conceptual views, the standardized operational views, and the sociocultural views. The nature of digital literacy can be seen as the amalgamation of information, technology, cognitive and sociocultural strengths, including basic computer skills, network literacy and digital problem solving and the like. In general, digital literacy is comprised of general literacy and interdisciplinary literacy. Among them, general literacy refers to the use of digital platforms and tools, and the evaluation, sharing and exchange of digital resources. Interdisciplinary literacy means the integration of curriculum in different disciplines and learning contexts.

**Educational practices of digital literacy.** Different from previous studies at the macro level, much of the focus on digital literacy in recent years has gradually shifted from ontology discussions to practical approaches. The current research concentrates on the real status of individual digital competence in higher education institutions at the micro level. Generally, it could be grouped into 4 categories, which cover the assessment of learners' perceptions and level of digital literacy, the investigation of influential factors of learners' digital competence, the relationship between digital literacy and

learners' achievement as well as the use of pedagogical approaches in digital literacy education. It should be noted that the assessment of university students' digital literacy has been a focus in higher education settings as digital literacy is an essential component of monitoring their learning achievement [36]. To some extent, the findings obtained from educational practices proved to be constructive for higher education institutions as they could be possible to design evaluation rubrics and applicable digital literacy frameworks in different contexts.

**Effectiveness evaluation of digital literacy during the COVID-19 pandemic.** The emergence of a novel coronavirus actually brought a huge impact on higher education, which posed a great challenge to university administrations, teaching faculties and students. Due to the confinement caused by the COVID-19 pandemic, it has made digital enhanced learning and teaching a necessity to support the functioning of the educational system [4]. The need for effectiveness evaluation of digital literacy among teachers and students became the hotspot, which attracted universal social attention [12]. Some studies attempted to analyze the beliefs and perceptions of teaching faculties on their digital literacy, and further investigated the level of digital teaching and learning competence in the time of the pandemic [37]. Some studies were conducted to explore the influence of digital tools and social networks on the learning competence of college students during the health crisis caused by COVID-19 [39]. Therefore, it was proposed to design personalized training plans to enhance the digital competences of teachers and learners in the post-pandemic time in high education.

So it can be concluded that the advancement of digital technology plays a significant role in the acquisition of digital literacy, which speeds up the transformation of digitalization at the higher education level. At the same time, with the improvement of individual digital competence, teaching faculties and students are supposed to adjust their teaching and learning modes so as to make full use of digital technology and resources.

The present study has its limitations. First, it is limited by the data source used. Only articles indexed in the database of Scopus were included. In future research, more scientific publications from other data sources such as Web of Science or EI Compendex should be analyzed. Second, it is limited by the query terms. If a retrieved item does not use any of the search terms in its title and abstract, it will not be included in the study, which might unintentionally leave out a small number of items. However, we believe that it will not significantly influence the results of this study.

## 5 Conclusion

Overall, there has been a growing interest in issues related to digital literacy research in higher educational contexts during the past decades. Production output of digital literacy remained relatively steady from 2012 to 2017, and experienced rapid growth during the recent 4 years from 2018 to 2021. American and European countries/regions took leading positions with a considerable number of publications and extensive funding sponsors. Digital literacy research mainly centered on the fields of education, information, and technology. Moreover, according to the authors' publications, most of

the prolific authors were from Spain that contributed most to the subject, and the Spanish author Guillén-Gámez ranked first with 8 articles across the examined period. According to the results of keyword co-occurrence, “digital technology”, “information literacy” and “digital literacy” were among the most frequently used keywords. All in all, the findings of the study could help researchers gain a comprehensive understanding of digital literacy, decipher the most frequently addressed themes in the field, and provide directions and references for future research.

## 6 Acknowledgement

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