



Research on Digital Competence in Education Domain from 2015 to 2024: A Bibliometric Analysis Based on CiteSpace

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Abstract. In education domain, digital competence has become one of the key skills that students should possess in the 21st century, helping them adapt to learning and life in the digital age. This study, based on the Web of Science database, employed the CiteSpace visualization analysis tool to review 389 papers published over the past decade. It systematically analyzed the research status and hotspots of digital competence in education domain. The results indicated that the number of research papers on digital competence in education domain has been increasing. Research efforts in this area are primarily concentrated in Spain. However, a collaborative network with significant hubs has yet to be established. Keyword clustering analysis revealed that the three core research themes in this field are digital transformation and educational innovation, teacher digital competence and professional development, and digital literacy and learner development. An analysis of keyword burstiness suggested that over the past three years, research hotspots have shifted from exploring fundamental concepts to verifying and evaluating effectiveness at the application level. This trend reflects that the field is progressively deepening and expanding toward more practical applications.

Keywords: Digital Competence, Education Domain, CiteSpace.

1 Introduction

The rapid development of digital technology is accelerating the process of digital transformation in various industries. In education domain, digital transformation has become a key driving force for educational change, which demands that teachers and students possess the necessary digital competence to achieve high-quality digital education [1]. Digital competence are equally important for both teachers and students. Teachers with strong digital competence can use digital devices more efficiently to conduct innovative educational activities, providing students with richer and more diverse learning experiences [2]. Similarly, students with digital competence can significantly enhance their learning efficiency and better adapt to the demands of digital

learning [3]. Therefore, in the 21st century, digital competence have become an crucial foundation for both teachers and students to adapt to future educational developments [4].

Digital competence can be defined as a comprehensive system of abilities that encompasses knowledge, skills, attitudes, strategies, and values, aimed at enabling users to fully and efficiently use digital technologies to perform tasks, solve problems, and communicate effectively [5]. Digital competence are not limited to the mastery of technical knowledge and application of specific skills, but also involve a range of strategic thinking and values that are crucial for effective utilization of digital technology and ethical interaction in the digital environment [6].

Among the concepts related to digital competence, digital literacy and digital skills are two frequently mentioned terms [7]. Although these two terms may be used interchangeably in some cases, they have certain differences in specific application scenarios. Digital literacy emphasizes individuals' ability to recognize, understand, evaluate, and apply digital information in the digital environment. It focuses on the field of education, emphasizing individuals' critical thinking and information processing abilities towards digital information [8]. In contrast, digital skills focus more on practical operational abilities, including the proficient use of specific digital tools and technologies. These skills are typically applied in workplace scenarios to support career development [9].

In education domain, digital literacy and digital competence have different origins and meanings. However, they are synonymous in conceptual definition and are sometimes used to support each other [2]. The cultivation of digital competence is a key element in improving students' comprehensive literacy, aimed at helping them adapt to the learning and lifestyle demands of the digital age.

2 Research Problems

In recent years, research on digital competence in education domain has gradually received widespread attention. Researchers have explored digital competence from various perspectives, including establishing standards, evaluating competence levels, and analyzing influencing factors [1]. However, over the past decade, there has been a lack of a comprehensive macro-perspective to synthesize the research progress in this field. Therefore, it is highly significant both theoretically and practically to review the current status of digital competence and to explore future trends. This study used CiteSpace to conduct a visual analysis of digital competence from 2015 to 2024, aiming to address the following questions:

1. What is the current status of digital competence in education domain?
2. What are the hotspots of digital competence in education domain?

3 Research Methods

The data for this study were sourced from the SSCI database within the Web of Science (WOS) Core Collection. During the screening process, the study established the

following search criteria: entering the keywords “digital competence” and “education” in the topic field, limiting the publication years to 2015–2024, restricting the document type to “Article”, and specifying the language as “English”. After rigorous screening, a total of 390 eligible articles were ultimately obtained. The study conducted a bibliometric analysis of 390 articles using CiteSpace (version 6.1.R4). During the analysis, the system identified 389 articles that met the quality requirements and performed a visual analysis of these articles. Through this analysis process, the study presents the current research status and hotspots of digital competence in education domain.

4 Result and Discussion

4.1 Number of Annual Publications

The change in the number of publications is an important indicator for measuring the development of digital competence in the education domain. The annual publication numbers in WOS database showed an increasing trend from 2015 to 2024 (see Fig. 1). This trend indicates that research on digital competence has transitioned from slow to rapid growth over the past decade. Particularly since 2020, the significant increase in publications has further highlighted the popularity and importance of research in this field. This suggests that the outbreak of COVID-19 has prompted the academic community to pay more attention to this area. In 2024, the number of publications in this field reached 81, which not only signals a new round of development in digital competence but may also profoundly impact education policy adjustments and school teaching reforms.

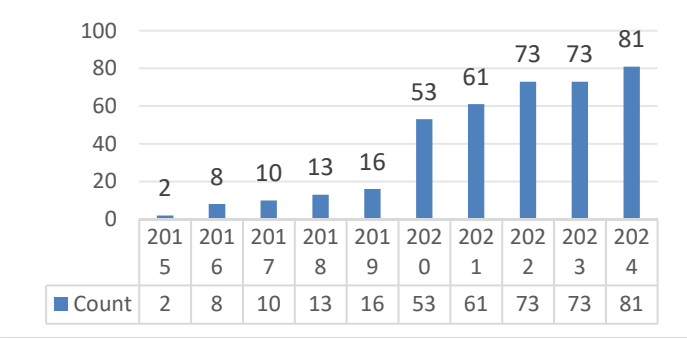


Fig. 1. The number of publications of digital competence in education domain.

4.2 Author Collaboration Analysis

Using authors as node types, the study automatically generated an author collaboration network graph for digital competence in education domain. As shown in Figure 2, the collaborative relationships among authors of research on digital competence are not significant, and a large collaborative group of authors has yet to form. This indicates that the collaborative research network in this field is still immature and has not

yet developed into an influential academic community. This phenomenon suggests that, although the importance of digital competence is increasingly prominent, the degree of cooperation in related research still needs to be enhanced. In the future, it will be necessary to further strengthen cross-institutional and cross-regional academic cooperation to promote the in-depth development of this field.

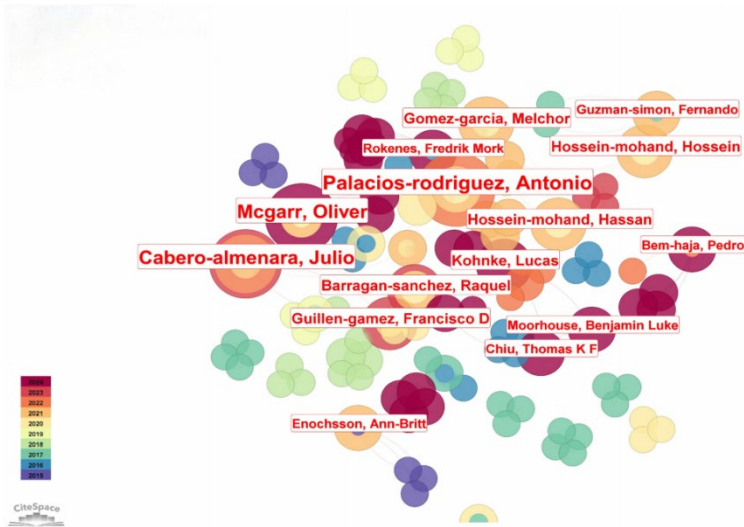


Fig. 2. The co-occurrence map of authors on digital competence in education domain.

4.3 Institutional Collaboration Analysis

The study employed CiteSpace to conduct a co-occurrence analysis of the main publishing institutions on digital competence in education domain. The resulting institutional co-occurrence network consists of 194 nodes and 183 connections, with a network density of 0.0098. As shown in Figure 3, the betweenness centrality of all nodes is below 0.1. This result indicates that, although some cooperation exists among institutions, the overall level of cooperation is relatively low, and no institutions have yet emerged as important hubs. This suggests that future research could further enhance the development of digital competence in education domain by strengthening inter-institutional cooperation.

In the graph, the size of the different nodes reflects the number of publications from each institution. The study found that the top three institutions are all from Spain. This phenomenon not only indicates that Spanish educational research institutions occupy an important foundational position in the study of digital competence but also reflects the significant academic influence of their core author group in this field. Therefore, educational research institutions in Spain play a crucial role in research in this field. In the future, international cooperation could be further strengthened to enhance the research level on a global scale.

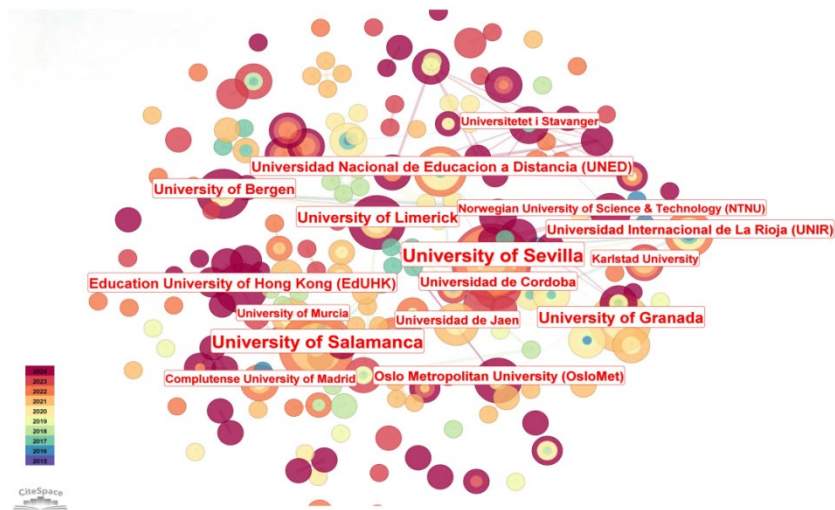


Fig. 3. The co-occurrence map of institutional on digital competence in education domain.

4.4 The Regional Distribution Analysis

By analyzing the regional distribution of digital competence in education domain, the global layout of research forces in this field can be clearly presented. This provides important references for future academic cooperation and research directions. From 2015 to 2024, Spain ranked first in the number of publications in this field, with a total of 157 articles published (see Table 1). This indicates that Spanish researchers have invested considerable effort into the study of digital competence in education and have achieved significant results. In contrast, China ranks second with 42 published articles, which is a substantial gap compared to Spain. This phenomenon suggests that Spain has demonstrated a stronger research interest and richer academic output in the field of digital competence in higher education.

Table 1. The top 10 countries regarding publication number of digital competence.

No.	Countries/Regions	Count
1	SPAIN	157
2	PEOPLES R CHINA	42
3	NORWAY	33
4	SWEDEN	21
5	GERMANY	18
6	IRELAND	16
7	FINLAND	14
8	USA	11
9	TURKEY	10
10	AUSTRALIA	9

4.5 Keywords Analysis

The study conducted keyword co-occurrence analysis on digital competence in education domain, and calculated the frequency and betweenness centrality of keywords. Table 2 presents the characteristics of the top ten keywords, with word frequencies greater than 33 and betweenness centrality greater than 0.16. These keywords mainly cover two levels: higher education and secondary education. They involve teachers and student groups and are closely related to information technology. This result indicates that current research on digital competence in the field of education not only focuses on practical applications at different levels of education, but also highlights the important role of information technology in the educational process, as well as the key roles of teachers and students in digital transformation.

Table 2. Top 10 frequency and centrality keywords on digital competence.

No.	Keywords	Co-Cited Frequency	Keywords	Centrality
1	digital competence	194	barriers	0.38
2	technology	91	literacy	0.36
3	education	90	digital literacy	0.27
4	higher education	72	beliefs	0.25
5	ict	60	information	0.23
6	students	39	engagement	0.20
7	teachers	38	secondary education	0.17
8	teacher education	35	policy	0.16
9	skills	34	natives	0.16
10	knowledge	33	communication	0.16

4.6 Keyword Clustering Analysis

The study used the clustering function of CiteSpace to draw a keyword clustering map for research on digital competence in education domain (Table 3). The module value Q of the clustering graph is 0.7432 (>0.3), and the average silhouette value S is 0.8991 (>0.7), indicating that the clustering results are highly rational and significant. By using keywords and the LLR (log-likelihood ratio) algorithm to extract clustering labels, a total of 15 clustering results were obtained. Based on the sorting of clustering nodes in the graph, combined with relevant keywords and literature for in-depth analysis, this study concludes that from 2015 to 2024, research on digital competence in education domain will mainly focus on the following three aspects.

Digital transformation and educational innovation. This theme focuses on the development and utilization of digital resources in the education domain. These research directions emphasize the importance of optimizing teaching quality and learning outcomes through digital technology, further focusing on the cultivation of 21st-century skills and the practice of digital stewardship. It reflects the widespread application of digital technology in education domain and its driving role in educational innovation.

Teacher's digital competence and professional development. These studies involve the training needs of teachers, the application capabilities of information and communication technology (ICT), and the digital transformation of social science education. They emphasize the professional development needs and training paths of teachers in the digital environment. The studies further focus on key elements such as 21st-century skills, teaching effectiveness, learning technology, and professional standards, revealing the professional development needs of teachers in terms of digital competence.

Digital literacy and learner development. These researches emphasize the necessity of digital literacy for learners to adapt to the digital age. Keywords such as digital citizenship, 21st-century learning skills, second language acquisition, and future teachers reflect the importance of digital literacy in civic education. The concepts of digital inclusion and digital informal learning further reveal the profound impact of digital technology in education domain, especially in the new normal, where the cultivation of digital literacy has become a key direction for educational development.

Table 3. Keyword clustering analysis of the digital competence in education domain.

Clusters	Size	Silhouette	Top terms
#0 new normal	28	0.744	new normal; digital inclusion; citizens; digital informal learning; Chinese teachers
#1 educational context	25	0.817	Educational context; education for sustainable development; educational technology; physical education; classroom teachers
#2 teacher training	23	0.977	teacher training; initial teacher training; information and communication technologies; computer uses in education; social studies education
#3 citizenship education	23	0.915	citizenship education; digital citizenship; twenty-first century learning skills; second language acquisition; future teachers
#4 digital literacy	22	0.909	digital literacy; digital skills; information literacy; higher education; communicative competence
#5 digital transformation	20	0.92	digital transformation; digital resources; teaching competences; pedagogical models; teaching-learning process
#6 professional digital competence	20	0.811	professional digital competence; 21st century abilities; efficacy; learning technologies; standards
#7 ict integration	19	0.878	ict integration; content analysis; pls structural equation modeling; science and technology; teacher portrait
#8 network analysis	18	1	network analysis; primary and secondary

			education; augmented reality (ar); machine learning; equity
#9 blended learning	16	0.958	blended learning; distance learning; case study; teaching skills; collaborative platform
#10 professional development	16	0.956	professional development; programming; mathematics; computational thinking; teacher educators
#11 digital technology	15	0.968	digital technology; education; information technology; 21st century skills; digital care
#12 self-determination theory	15	0.876	self-determination theory; learning; online learning; teachers digital competence; ai
#13 technology adaptation	14	0.885	technology adaptation; internet access; science/technology/engineering literacy; bayes factors; information
#14 teacher education	9	1	teacher education; digital competence; student teachers; early childhood teacher education (ecte); intelligent pedagogical assistance system
#15 motor impairments	7	1	motor impairments; educational games; human-computer interface; natural interaction; digital competence

4.7 Analysis of Keyword Burstiness

Burstiness of keywords refers to a significant increase or decrease in the frequency of occurrence of keywords during a specific period of time, and is an important indicator of the evolution of research hotspots. The analysis results show that a total of 15 keywords exhibit significant emergence phenomena (see Fig. 4). Among these emergent keywords, the strongest one is “native”, followed by “literacy”, and the third is “information”. The emergence of these keywords indicates a significant increase in attention to these concepts in related research over the past period, reflecting the dynamic changes in research hotspots. Further analysis of the research hotspots in the past three years reveals that is gradually shifting towards keywords such as “work”, “validation”, and “effectiveness”. This change reveals the latest trend in research in this field, which is gradually shifting from exploring basic concepts to verifying and evaluating effectiveness at the application level. This reflects the deepening and expansion of digital competence research in education domain.

Top 15 Keywords with the Strongest Citation Bursts

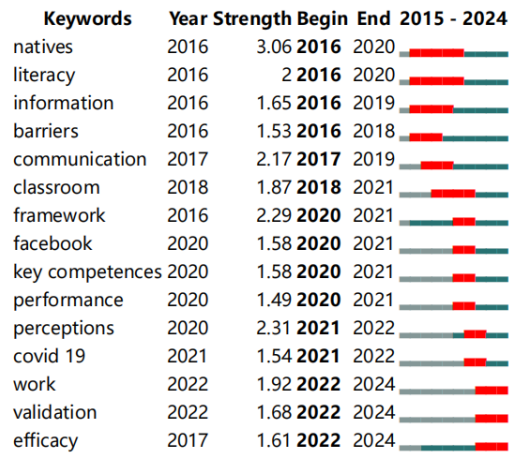


Fig. 4. The keyword burstiness map of digital competence in education domain.

5 Conclusion

This study used the CiteSpace to analysis 389 articles focusing on digital competence in the education field from the WOS and conducted visual analysis to explore the research status and hotspots over the past decade. By analyzing the number of publications, authors, institutions, countries, and collaborative networks, the current research landscape has been revealed. Meanwhile, through keyword analysis, cluster analysis, and keyword burstiness analysis, the research hotspots in this field have been further presented.

The study found that the number of papers on research related to digital competence in education domain showed an upward trend. Through analysis of author publications, authoritative scholars and research teams in the field have been identified, with Spanish scholars having a particularly prominent influence and making important contributions to the development of the field. Through visual analysis of the number of publications by countries and institutions, it was found that the current research force in this field is mainly concentrated in Spain, but the degree of cooperation between institutions is relatively low, and a significant hub network of cooperation has not yet been formed.

Keyword frequency analysis showed that the top ten keywords mainly focusing on groups with digital competence and the importance of information technology in the education sector. The clustering analysis results indicate that research on digital competence in education domain mainly focuses on three themes constitute the core research content of this field. These research topics not only reveal the sources and

characteristics of digital competence but also reflect their close relationship with the enhancement of digital competence. Keyword burstiness analysis shows that in the past three years, the research hotspots in this field have shifted from exploring basic concepts to verifying and evaluating effectiveness at the application level. This trend reflects the latest developments and directions of digital competence is gradually deepening and expanding to more practical levels.

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