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A scientometric review of digital competency among educators during the past 10 years

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ABSTRACT

This study interest in examining the digital competency of educators in educational institutions. Digital competency is of utmost importance in today's technologically advanced society due to the pervasiveness of technology not only in the classroom but also in our daily lives. This study analyzed 1,189 journal articles from the Scopus database based on bibliographic coupling and co-word analysis using bibliometric analysis. The period of time covered by the study was from 2013 to 2022. Findings indicated that there has been an increase in the number of studies concentrating on digital competency among educators, with this increase becoming more pronounced during the COVID-19 outbreak. Significant themes emerged in relation to educators' digital competence, particularly concerning the significance and global impact of these characteristics. Bibliographic coupling yields five clusters for current research, whereas co-word analysis yields four clusters for predicting future trends. As a result, some suggestions were made with the intention of contributing to the relevant research community based on study's findings.

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1. INTRODUCTION

Rapid technological development in the 21st century is unquestionably transformative and has the potential to have a substantial impact on many facets of our lives. Technology is transforming the landscape of education, facilitating new forms of learning and increasing access to educational resources. We have no option but to prepare ourselves by acquiring the essential skills and competencies for success in the contemporary world. Internet and digital technologies are now so widely used that they have become an integral part of our daily existence. Digital competence can be described as a set of skills to optimize our daily activities through technology [1], [2]. In line with the recommendations established by the European Union Council of 22 May 2018 regarding key competencies for lifelong learning, all citizens should develop digital competence as a core capability of continuous learning. They identify digital competence as one of the eight essential life skills. Immediately after, they created the European digital competence framework (DigComp), which provides a reference framework to support the development of digital literacy for

individuals to participate fully in the digital world [1], [3]. As demonstrated in digital competence of educators (DigCompEdu) [4], the studies have since evolved into an educational initiative that provides a reference for training and evaluation purposes.

Information and communication technology (ICT) is being embraced by educational institutions around the globe as one of the primary means to establish and maintain connections with diverse and dynamic teaching and learning at any time and place. The information society now faces new issues due to the ICT's rapid development, including the need to employ technology to prepare students for the real world and the continuously changing nature of the job market [5]. In this regard, ICT plays a significant role in the development of educators' generic competencies [6], [7]. They should be proficient in producing and managing digital material for educational purposes while also serving as role models for students by exhibiting appropriate and ethical technology use [8]-[12].

The research literature on digital competence has gained enormous traction in educational practice and most scholars had agreed that it is growing at a fast and steady pace [13], [14]. The COVID-19 pandemic saw a quick transition to emergency remote teaching (ERT), making educator digital competency a requirement for everyone. Universities immediately expanded their offering of digital services and transitioned their support, teaching, and learning processes to the online environment [15], [16]. The pace and scope of this response put heavy demands on the online learning [17], [18]. The ERT practices accelerate the attention towards educators' digital competence (EDC) and thus, there is a need to better understand the trends shown by past and current studies to helps this inform future practices.

The interest in digital competence in educational context has led to a proliferation of literature over the past decade [19], [20], and the purpose of this study was to produce an abundance of reviews on the subject. From the inception of digital competence to its current level, the literature is traced, taking into account the recent rise in research brought on by the COVID-19 pandemic. This methodology will assist researchers in exploring and gaining a deeper comprehension of this field, as well as in predicting future EDC trends. In addition, this study will ascertain the focus of previous studies conducted over the past decade, as well as the relationship between the influential clusters and themes of EDC adoption that may be relevant in future years, even after COVID-19 subsides.

This study proposes conducting a quantitative literature review utilizing bibliometric analysis of the Scopus database. Even though other studies [13], [21] have utilized a similar methodology, the visualization of digital competency over the past decade has contributed to a better understanding of the knowledge divide. The three studies are deficient in certain respects, as they focus solely on studies from the Web of Science database and limit their search string to "digital competence and teachers" [13], thus excluding the overwhelming majority of relevant publications. Cisneros *et al.* [22] focuses on EDC in postsecondary education, whereas Baber *et al.* [21] presented non-educator-specific digital competency literature published from 2017 to 2022. To the best of the author's knowledge, none of these previous studies are specific to the context of all educators, regardless of schools or higher education institutions, making this review the finest of its kind. Through bibliographic coupling and co-word analysis, this study proposes such an approach. The following research objectives are therefore presented: i) to access the present knowledge on digital competency among educators through bibliographic coupling; and ii) to discover the trends and directions of studies on digital competency among educators through co-word analysis.

2. METHOD

2.1. Bibliometric analysis

The bibliometric approach is a quantitative strategy that employs a scientometric review to analyze bibliographic databases [23], [24]. The development of bibliometric software like VOSviewer, Leximancer, and Gephi contributed to its popularity. It is also due to the development of scientific databases such as Scopus, PubMEd, and Web of Science. Various disciplines, including educational policy and leadership [25], [26], educational technology [24], [27] and educational psychology [28], [29] have utilized the method. This study utilized the following two bibliometric analyses:

i) Bibliographic coupling: A method for measuring the similarity or relationship between publications based on their shared references. This analysis reveals the relationship between cited publications [23], [30]. Using this methodology, it is possible to visualize recent contributions that have not yet had a significant impact, thus reflecting the most recent scientific output in the field [31]. In this study, this analysis is used to evaluate the present knowledge structure regarding educators' digital competency over the past decade.
ii) Co-word analysis, also known as co-occurrence of keywords, is a technique used to evaluate the relationship between keywords. The keywords are extracted from the title, abstract, and other keywords of the publication [32]. Based on the analysis's notable terms, future research disciplines and directions can be predicted [23], [33]. Prior to this research, this analysis evaluates the trajectory and trend of educators' digital competence over the past decade.

2.2. Data collection method

This study used the search phrase shown in Table 1 to classify relevant publications on i) educators; ii) digital competence; and iii) the previous 10 years by using the "TITLE-ABS-KEY" and "PUBYEAR" search options in the Scopus database. This study concentrates on queries from article titles, keywords, and abstracts in order to highlight the relevant issue that is crucial prior to the need for research [34]. Using AND Boolean operators to link two spheres, the two primary keywords were identified. In order to broaden the result, searching keywords are expanded by using additional related and synonym words and terminologies identified from other literatures, and dictionary and thesaurus.

Only journal articles were included to assure the quality of the retrieved database, and all other types of publications (books, book chapters, conference proceedings, editorials, and white papers) were excluded. Limiting journal publications ensures high-quality, peer-reviewed publications are further analyzed when presenting the topic's actual knowledge structure [35], [36]. As part of the data set, CSV-formatted data was exported and the bibliometric software VOS viewer version 1.6.18 was used to analyze the texts in order to determine the citation metrics and various other rates.

Table 1. Keyword search string from Scopus

No	Keywords	Rationale
1	"teacher*" OR "educator*" OR "lecturer*"	To identify literature limited to educators.
2	"Digital competency" OR "digital competencies" OR "digital competence" OR "digital skill*" OR "digital proficiency"	To identify literature related to digital competency.

3. RESULTS AND DISCUSSION

Data of this study were extracted on May 23, 2023. The initial record yielded 1,828 results. Further exclusions were made after limiting the source type into journal articles and 1,189 articles were found after this search. There are 12,285 citations in total. These publications have an h-index of 54, meaning that 54 of the 1,189 articles considered for the h-index have been cited at least 54 times. The number of articles and citations based on keywords applied to the database is depicted in Figure 1. From 2013 to 2019, fewer articles were published and cited regarding digital competence among educators. There is a surge in publications and citations during the Covid-19 epidemic, which spans the years 2020 to 2022. This trend indicates that researchers are actively engaged in EDC research and recommending more in the future years, as this field is pertinent to the development of technology use in educational context [37], [38].

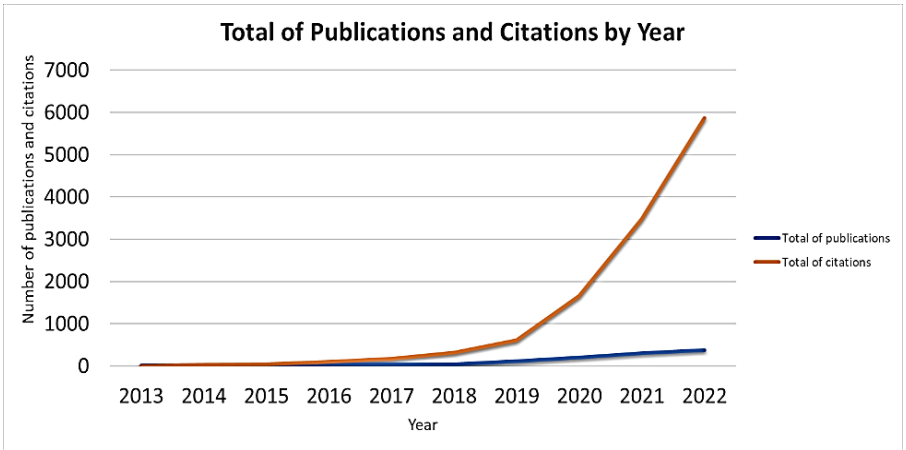

Figure 1. Number EDC-related publications and citations

3.1. Bibliographic coupling

A total of 51 articles out of 1,189 satisfied the minimum citation requirement of 58. These 51 articles were divided into five clusters. Multiple experiments were conducted to establish the thresholds in order to ensure the clusters' dependability. The analysis excludes articles with a bibliographic coupling frequency below the threshold. A threshold that is too high would result in over-filtering, whereas a threshold that is too low would result in under-filtering and the construction of an excessive number of clusters [39].

Given that bibliographic coupling depends on citing publications, influential publications should be identified using total link strength (TLS). Using the entire number of citations would be detrimental to more contemporary works [40]. In this study, Røkenes *et al.* [41] (TLS=100), Reisoğlu and Cebi [42] (TLS=94), and Gudmundsdottir and Hatlevik [43] (TLS=82) are the top three articles based on TLS. Table 2 lists the top 10 articles according to the bibliographic coupling analysis.

The network visualization of bibliographic coupling is depicted in Figure 2. The five clusters are manifestly distinct from one another. EDC current trends and prospective development are discussed. The clusters' themes are derived from an inductive interpretation of representative cluster articles and a synthesis of common themes and research strands.

Table 2. Top 10 articles in bibliographic coupling analysis

No.	Author(s)	Citation	Total link strength
1.	Røkenes *et al.* [41]	83	100
2.	Reisoğlu and Çebi [42]	59	94
3.	Gudmundsdottir and Hatlevik [43]	180	82
4.	Starkey [44]	100	70
5.	Hatlevik [45]	88	68
6.	Tømte [46]	84	62
7.	Martín *et al.* [47]	66	60
8.	Instefjord and Munthe [48]	78	60
9.	Pettersson [49]	142	57
10	Hatlevik *et al.* [50]	87	52

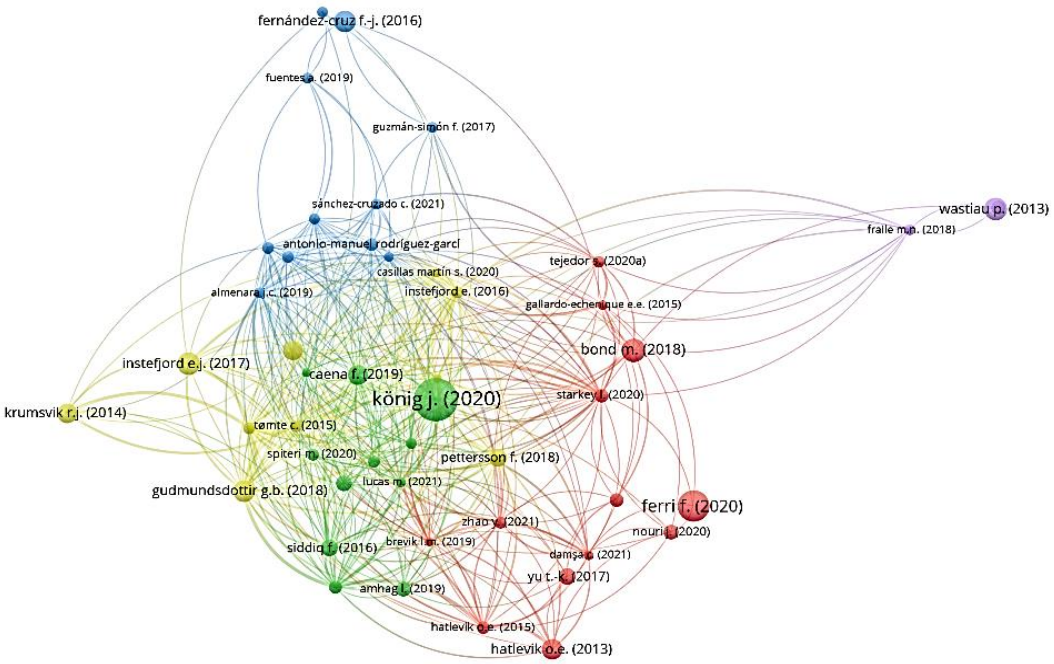

Figure 2. Bibliographic coupling of EDC

On the basis of the researcher's inductive interpretation, the first three clusters are further developed. The following explanation was given for the clusters:

– The largest cluster, cluster 1 (red) has 13 articles with the following themes: "navigating the digital frontier: overcoming challenges to develop digital competence". According to their agency, educators' propensity to engage in transformative action despite constraints varies. In an effort to overcome the obstacles, teachers who battled with institutional support and a lack of digital competency turned to their networks and colleagues for help as well as self-help [51]. Considering what educators went through during the COVID-19 pandemic, ERT faces three challenges consist of educational, technological, and societal challenges to ensure that all students have equal access to education [52]. Professionals must be endowed with digital competency skills due to the higher education sector's increased use of digital

technology. Bond *et al.* [53] discovered that during teaching and learning, a small number of digital tools are used by teachers and students for mostly assimilative work.

- Cluster 2 (green) has 11 articles and a theme of "unleashing the power of digital competence: empowering educators for transformative pedagogy". In order to produce digital teaching, teacher educators need a lot of pedagogical support because it has been found that they do not primarily employ digital tools for pedagogical goals. It is recommended that educators should use digital tools to find the pedagogical surplus value in their particular teaching and learning context in order to boost motivation, as demonstrated by seasoned educators [54]. The variance in general school ICT culture were greatly explained by some predictors consisting: i) the proportion of instructors who often use ICT in the classroom; ii) the use of technology to improve pedagogy; iii) teachers' digital competence; iv) teachers' creation of the content; v) its design by teachers; vi) pedagogical updating of class websites; vii) e-communication between faculty members; and viii) e-communication between teachers and parents. In addition, it is anticipated that the ICT culture of schools as a whole will endure substantial changes over time [55].
- Cluster 3 (blue) with 11 articles is themed as "empowering educators: cultivating excellence in the digital age". The assessment of the growth of teachers' digital competence reveals a lack of teachers' ability to produce digital material and ineffective ICT trainings, both of which contribute to the enduring difficulties in the growth of teachers' digital competence [56]. Improving quality and educational performance is not only dependent on the availability of ICT to consume knowledge, but also to enrich, create, and produce it. In this regard, it is crucial to invest in professional development as a means of encouraging educators to utilize technology differently [57]. Collaborative learning and authorship are essential for fostering the professional growth of university instructors and the digital literacy of their students. Similarly, it is essential to prioritize communication and collaboration during the teaching and learning process by utilizing helpful digital resources [58].

The cluster, theme, number of publications, and representative publications are included in the synopsis of related literatures on EDC in Table 3.

Table 3. A summary of the related literature on EDC from bibliographic coupling

Clusters	Theme	Number of publications	Representative publication
1 (red)	Navigating the digital frontier: Overcoming challenges to develop digital competence	13	[51]; [52]; [53]
2 (green)	Unleashing the power of digital competence: Empowering educators for transformative pedagogy	11	[54], [55]
3 (blue)	Empowering educators: Cultivating excellence in the digital age	11	[56], [57], [58]

3.2. Co-word analysis

The same database was used for the co-word analysis produces four clusters from 61 of 3,531 keywords that met 17 thresholds. The threshold was finalized after 15 trials in order to produce the most reliable and efficient network visualization, where this analysis depicts stable clusters. "Digital competence" (339), "teaching" (106), and "education" (100) are the three terms with the maximum frequency of co-occurrence. These three keywords have the highest TLS representation, correspondingly. The top 15 co-occurring keywords according to TLS in this study are presented in Table 4.

Table 4. The highest 15 keywords on EDC research

No.	Keywords	Occurrences	Total link strength
1.	Digital competence	339	770
2.	Teaching	106	578
3.	Education	100	520
4.	COVID-19	118	468
5.	Human	47	465
6.	e-Learning	96	453
7.	Higher education	154	449
8.	Teacher training	149	425
9.	Article	38	411
10.	Learning	57	341
11.	Students	72	335
12.	Teacher	46	320
13.	Humans	28	303
14.	ICT	121	271
15.	Adult	22	265

Figure 3 shows the co-word analysis's network structure. It clearly demonstrates four compact, interconnected clusters representing four distinct topics. Particularly, cluster 3 (blue) is integrated with cluster 2 (green) and cluster 4 (yellow), whereas cluster 1 (red) has the densest cluster and is intercorrelated with all three other clusters.

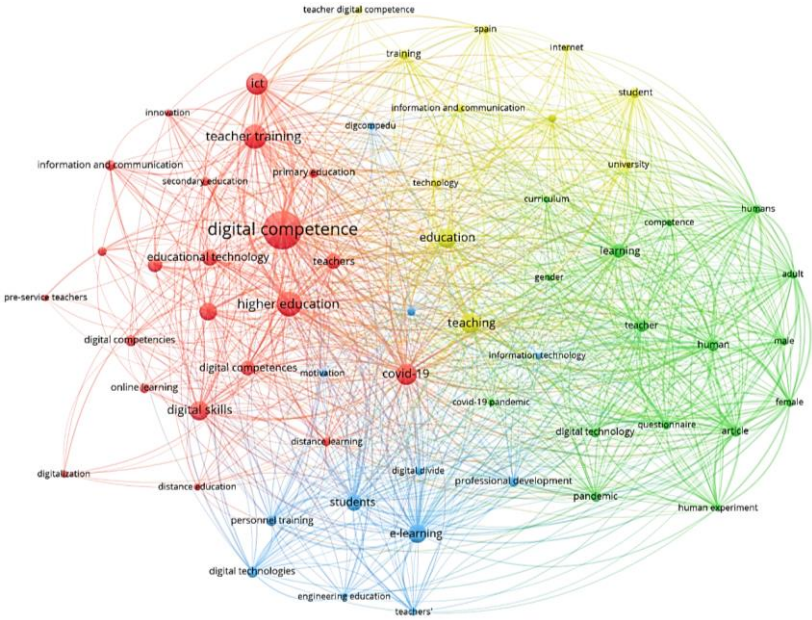

Figure 3. Co-word analysis on EDC

The first three clusters were discussed and themed according to researchers' interpretive evaluation. Each cluster were explained as:

- 22 keywords formed cluster 1 (red) which can be themed as "navigating the new normal: transforming education through digital competence and innovation". During the school closure, teachers encountered difficulties adapting to online teaching, and it was discovered that the teachers' digital competence, as well as educational opportunities to acquire digital skills, were crucial [59], [60]. Tejedor *et al.* [61] conducted a study primarily to examine how higher education institutions in three countries have responded to the global closure situation, with a focus on the development of digital literacy. To ensure digital literacy, the results suggest rethinking learning in higher education and reinforcing important issues such as communication, teaching, and digital competencies. In addition, in order to attain the optimal level of digital skills, a training program should be implemented specifically for teachers with a low perception of their own digital skills [38].
- Cluster 2 (green) is formed from 16 keywords, themed as "synergy of competence and digital technology: empowering human-centered learning in the digital age". To integrate digital technology and foster digital competence, schools need more than an ambitious curriculum and fundamental infrastructure [62]. This is due to the fact that teachers' use of technology in daily instruction was limited due to the limited availability of digital technology to support traditional teacher-centered practices, resulting in low pupil engagement. Technology-mediated education has been shown to enhance the learning process of students by enhancing their writing skills, comprehension, and application of new literacies [63]. Similarly, utilizing technology in libraries improves students' ability to learn significantly more than employing digital literacy instructors or introducing them to an ICT-based curriculum [64].
- With 12 keywords, cluster 3 (blue) is formed with "bridging the gap: empowering education in the digital era through DigCompEdu and motivation" theme. Technical and professional concerns were rated higher than pedagogical and digital competence-related concerns [65]. There were 115 secondary school music instructors in Spain reported that age, attitude towards ICT, and motivation in teaching practice are predictive variables for high technology competency in the classroom [6]. Digital competencies can be fostered among pre-service teachers by cultivating skills for information literacy collaboration, digital well-being, providing adequate digital competency trainings, and implementing hands-on experience [42].

The results from co-word analysis are summarized in Table 5 along with the cluster, theme, number of keywords, and representative keywords.

Table 5. Summary of the co-word study on EDC

Cluster	Theme	Number of keywords	Representative keywords
1 (red)	Navigating the new normal: transforming education through digital competence and innovation	22	COVID-19, digital competence, digital literacy, digitalization, distance education, educational innovation
2 (green)	Synergy Of Competence and Digital Technology: Empowering Human-Centered Learning in The Digital Age	16	Competence, curriculum, digital technology, human, learning, teacher
3 (blue)	Bridging The Gap: Empowering Education in The Digital Era Through DigCompEdu and Motivation	12	DigCompEdu, digital divide, e-learning, information literacy, motivation, professional development

4. CONCLUSION

Digital competency among educators discussed educators' knowledge, abilities, attitudes, and behaviors related to the efficient use of digital technologies in educational contexts. It entails having the skills to use digital resources, platforms, and technologies for learning, teaching, and career development. In this study, the search query pertaining to digital competency among educators was utilized to review the EDC-related journal articles published in the past decade. The bibliometric data of 1,189 articles in the educational research category of Scopus were analyzed and bibliometric performance and science mapping techniques were used to create a data set for the study. On the basis of the findings, three conclusions were drawn. First, more researchers are now looking towards EDC after 2019. In light of this, the fact that 896 of the total research articles were published in the last three years (2020: t=210; 2021: t=303; 2022: t=383) suggests that these years accounted for more than half of all EDC publications in the Scopus database. This may suggest that in order for educators to be prepared for the upcoming digital age, digital competency will become one of the most important core abilities.

Additionally, the COVID-19 pandemic has expedited the requirement for educators to improve their digital literacy in order to successfully engage students in distance learning situations. Even though this field has been gathering popularity since before the pandemic, it has reached its zenith now that all educators and students are required to participate in distance learning. Consequently, EDC research is anticipated to increase to meet the demand for digitalization in education. Through bibliometric coupling, the intellectual structure of the EDC knowledge base revealed the three most germane themes extracted from each cluster: i) navigating the digital frontier: overcoming challenges to develop digital competence; ii) unleashing the power of digital competence: empowering educators for transformative pedagogy; and iii) empowering educators: cultivating excellence in the digital age. These clusters showed that in order to maintain teaching and learning regardless of the situation, educators must remain adaptable and willing to learn new digital skills and use digital technologies. Through co-word analysis, the future trends of EDC have revealed the three most prominent themes extracted from each cluster: i) navigating the new normal: transforming education through digital competence and innovation; ii) synergy of competence and digital technology: empowering human-centered learning in the digital age; and iii) bridging the gap: empowering education in the digital era through DigCompEdu and motivation. These clusters suggested that in today's rapidly evolving digital landscape, digital competency is crucial for educators to meet the needs of 21st century learners.

Future research should investigate and expand upon the evaluations of the association between EDC and student learning outcomes. This research may explore how educators use digital tools, resources, and instructional strategies affect student engagement, achievement, and 21st century skill development. Research in this area can identify the most effective ways to integrate technology into instructional practices and design digital learning environment that promote student engagement, critical thinking, and academic achievement. Studies from different countries or regions are expected to contributes broaden body knowledge of EDC as different countries might differ in educational policies and initiatives regarding digital integration in schools. In addition, access to technology and internet connectivity varies significantly across countries that might give a different view towards EDC.

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