



REVIEW

Digital competences in primary and secondary education: a trend visualisation analysis through VOSviewer

Competencias digitales en educación primaria y secundaria: un análisis de visualización de tendencias a través de VOSviewer

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ABSTRACT

Introduction: in an increasingly interconnected society, digital skills are increasingly important in the education of the next generations. Therefore, it is necessary to know the main trends in this field of studies.

Method: this study conducts a trend visualisation analysis on digital competences in basic and secondary education, using the VOSviewer tool to map and visualise the relationships between authors, institutions, and research topics.

Results: the visualisation reveals a significant increase in scholarly output related to digital competences, especially from 2020 onwards. Co-authorship networks and keyword co-occurrence highlight central nodes of collaboration and emerging themes in this field of study.

Conclusions: the results underline the importance of an interdisciplinary approach and the need to strengthen digital competences in teacher education.

Keywords: Digital Competences; Basic and Secondary Education; ICT; Data Visualisation; VOSviewer.

RESUMEN

Introducción: en una sociedad cada vez más interconectada, las competencias digitales son cada vez más importantes en la educación de las próximas generaciones. Por ello, es necesario conocer las principales tendencias en este campo de estudios.

Método: este estudio realiza un análisis de visualización de tendencias sobre competencias digitales en educación básica y secundaria, utilizando la herramienta VOSviewer para mapear y visualizar las relaciones entre autores, instituciones y temas de investigación.

Resultados: la visualización revela un aumento significativo en la producción académica relacionada con las competencias digitales, especialmente a partir de 2020. Las redes de coautoría y la coocurrencia de palabras clave destacan los nodos centrales de colaboración y los temas emergentes en este campo de estudio.

Conclusiones: los resultados subrayan la importancia de un enfoque interdisciplinario y la necesidad de fortalecer las competencias digitales en la formación docente.

Palabras clave: Competencias Digitales; Educación Básica y Secundaria; TIC; Visualización de Datos; VOSviewer.

INTRODUCTION

Digitalization has significantly impacted all aspects of modern life, making digital competencies an essential skill not only for accessing information but also for participating in a globalized society. In the educational field, these competencies are particularly important, as teachers must not only acquire them for their professional development but also use them to enhance teaching and facilitate student learning. Authors like Selwyn⁽¹⁾ emphasize that digital competencies are not limited to basic technology use but also include the ability to employ it critically and effectively in pedagogical contexts. In this sense, training in digital competencies for teachers is essential to ensure that future generations can successfully navigate an increasingly digital environment.

Since the introduction of computers in classrooms during the 1980s, the evolution of digital competencies and technological education has been considerable. Bawden⁽²⁾ and Hargittai⁽³⁾ have documented how the nature of digital competencies has changed, reflecting the transformations in expectations and applications of ICT in education. With the growing adoption of advanced technologies such as artificial intelligence and adaptive learning, the need to develop robust digital competencies in teachers has become more urgent than ever.

The NMC Horizon Report⁽⁴⁾ provides a global perspective on how educational institutions in different parts of the world are adopting digital technologies. These international comparisons highlight variations in ICT implementation and educational outcomes, emphasizing the importance of cultural and economic contexts in the development of digital competencies. The integration of ICT in education has the potential to radically transform teaching and learning processes, facilitating methodologies that adapt to the individual needs of students and improving their outcomes. However, authors like Conole⁽⁵⁾ warn that the success of this integration largely depends on the ability of teachers to use these tools effectively.

Despite the opportunities that ICT offers, the challenges for its effective integration in classrooms are significant. Teachers' digital competence is a critical factor that can either facilitate or hinder this process, as evidenced by research from Jones & Shao.⁽⁶⁾ Teachers in primary and secondary education have a unique role in the educational system, as they are responsible for laying the foundations of formal learning. Their digital competence directly impacts the quality of education they provide and the preparation of students to face the challenges of the global digital economy.

To guide and standardize the acquisition of digital competencies in the educational field, several frameworks have been developed. Among the most prominent are the European Framework for the Digital Competence of Educators (DigCompEdu), proposed by Redecker⁽⁷⁾, and the standards of the United Nations Educational, Scientific and Cultural Organization (UNESCO)⁽⁸⁾. These frameworks provide detailed structures for the assessment and development of critical skills in educators and are essential for designing educational policies that promote the effective integration of ICT in classrooms.

However, despite significant advances in research on digital competencies, important gaps in knowledge persist, particularly regarding the variability of these competencies among teachers globally. The differences between developed and developing countries are particularly notable, and inequalities in training and ICT implementation can perpetuate or even exacerbate the educational gap between these regions. It is essential to investigate how digital competencies are developed and applied in diverse economic and cultural contexts, as this can provide valuable insights for the design of more inclusive and effective educational policies.

The field of digital competencies in education has garnered increasing interest within academic research, as reflected in the rise in publications in recent years. However, despite this interest, advanced data visualization techniques, such as those offered by VOSviewer, a tool developed by Van Eck & Waltman⁽⁹⁾, remain underutilized in the analysis of this area. These tools are essential for deepening the understanding of trends, patterns and the evolution of research on digital competencies. According to Cobo & Moravec⁽¹⁰⁾, the use of visual analysis tools allows not only mapping existing knowledge but also identifying interconnections and gaps in the field, which is crucial for the development of more effective educational strategies.

The main objective of this study is to conduct a comprehensive analysis of the literature on digital competencies in elementary and secondary school teachers using VOSviewer. Through this data visualization approach, the study aims to identify key areas and emerging trends in the research, as well as to recognize influential authors and the collaborative networks leading this field. As noted by Small⁽¹¹⁾, Börner⁽¹²⁾, and Leydesdorff⁽¹³⁾, network analysis and data visualization are powerful methodologies for revealing the underlying dynamics in knowledge production, enabling researchers to identify critical areas that require more attention. This methodological approach not only reveals current trends but also highlights underexplored research areas, providing a solid foundation for more effective future educational interventions and policies.

METHOD

Study Methodology and Bibliometric Approach

This study applied a bibliometric approach to quantitatively investigate publications on digital competencies in primary and secondary education. The research, descriptive in nature, adopted a retrospective design that facilitated the quantitative interpretation of the data. Ethical consent was not required, as the study was

exclusively documentary and based on publicly accessible data. The methodology of this study focuses on a comprehensive bibliometric analysis of the literature on digital competencies in primary and secondary school teachers.

Data Selection

To ensure a representative and relevant analysis, specific search terms were employed to capture the most pertinent literature in this field. Terms such as Digital competencies/Teachers/Basic and secondary education, Digital competencies/Teacher/Basic and secondary education, Digital Competence/Teacher/Basic and secondary education, Digital competence/Teacher/Education, Digital competence/Teacher/Education, Digital competencies in basic and secondary education, Digital Competencies-Teacher or Professor-Basic and Secondary Education in Colombia were used, both in English and Spanish.

Additionally, combinations of terms were performed using Boolean operators to further refine the search, ensuring the comprehensive inclusion of relevant publications. These terms were applied in the title, abstract, and keyword fields of the records available in the selected databases.

To ensure the relevance and quality of the included studies, several filters were applied, including the restriction to peer-reviewed publications, the exclusion of conference proceedings and editorials, and a time limitation to the last twenty years (2003-2023), coinciding with the rise of ICT in education. Finally, the focus was specifically on studies that explicitly addressed the context of primary and secondary education, both globally and in specific national contexts, such as Colombia, to enable a more in-depth and contextualized analysis.

Analysis Tools

The analysis of trends in research on digital competencies was conducted using VOSviewer, a tool widely recognized in the academic field for constructing and visualizing bibliometric networks, developed by Van Eck & Waltman⁽⁹⁾. This software allows for the identification of relationships between authors, institutions, and keywords, providing a clear visual representation of the most researched topics and their interrelationships. Its ability to handle large volumes of bibliographic data and generate detailed maps makes it an essential tool in bibliometric and scientometric studies.

The intelligent local moving algorithm implemented in VOSviewer has proven to be particularly effective for detecting communities in large-scale networks. When using VOSviewer for the visualization of trends and network analysis, a deeper understanding of the dynamics and evolutions in this field of study was achieved, where the relationships between words were represented as links and distributed as closely spaced points in a multidimensional space. Previous studies have demonstrated the effectiveness of bibliometric techniques for mapping knowledge, identifying critical areas, detecting emerging trends, and establishing the state of the art in specific fields of research.^(15,16,17,18) For instance, in digital education, reinforcing the relevance of this method for analyzing specialized literature and guiding future research.

VOSviewer Setup for Analysis

Data Preparation and Exportation

The data were collected and organized in compatible formats (RIS and CSV), ensuring that all relevant information, such as citations, co-authorship, and keywords, was available for analysis in VOSviewer. This approach is supported by Boyack & Klavans⁽¹⁹⁾, who emphasize the importance of accurate data export to ensure reliability in bibliometric analyses. This analysis allowed for the visualization of how researchers in the field of digital competencies collaborate with each other, revealing central nodes representing key authors with multiple collaborations and high scientific productivity. These nodes were evaluated in terms of their centrality and contribution to the field, following methodologies recommended by authors such as Van Eck & Waltman.⁽²⁰⁾

Co-Authorship Analysis

The co-authorship function in VOSviewer was used to identify collaboration networks and influential authors in the field of digital competencies. This analysis allowed for the visualization of how researchers collaborate with each other, revealing central nodes that represent key authors with multiple collaborations and high scientific productivity. Newman^(21,22) and Liu et al.⁽²³⁾ have emphasized the usefulness of co-authorship networks for understanding the collaboration structure within a field of study.

Keyword Co-Occurrence Analysis

In addition to the co-authorship analysis, a co-occurrence analysis of keywords was conducted to identify emerging themes and trends in research on digital competencies in education. This analysis maps the frequency and proximity of keywords in the selected articles, providing a visual representation of the most researched concepts. Callon et al.⁽²⁴⁾ emphasize the importance of co-occurrence analysis in revealing thematic interrelations within a research field. This approach allows for the detection of patterns in the literature, such

as emerging subfields of research or areas that require further attention.

Density Maps and Thematic Networks

VOSviewer was configured to generate density maps and thematic networks, which were analyzed to visualize both the areas with the highest concentration of research and the connections between different topics and authors. These maps helped identify thematic clusters and areas requiring further exploration, and they also provided a basis for future research by highlighting areas that need more exploration. Börner et al.⁽²⁵⁾ and Chen et al.⁽²⁶⁾ have demonstrated how density maps and thematic networks can be used to identify emerging areas and gaps in research.

RESULTS

In this section, the key findings of the bibliometric analysis conducted on the literature related to digital competencies of elementary and secondary school teachers are presented. The results are organized based on the visualizations generated through VOSviewer to facilitate the understanding of emerging trends in this field of study.

Figures and Maps of VOSviewer

The visualization of networks generated by VOSviewer provides a clear view of the connections and collaborations within the field of study. In particular, the following were carried out:

Academic Collaboration in Digital Competencies Research

Figure 1 below illustrates academic collaboration in digital competencies research, highlighting the co-authorship network and the authors involved in this field of study.

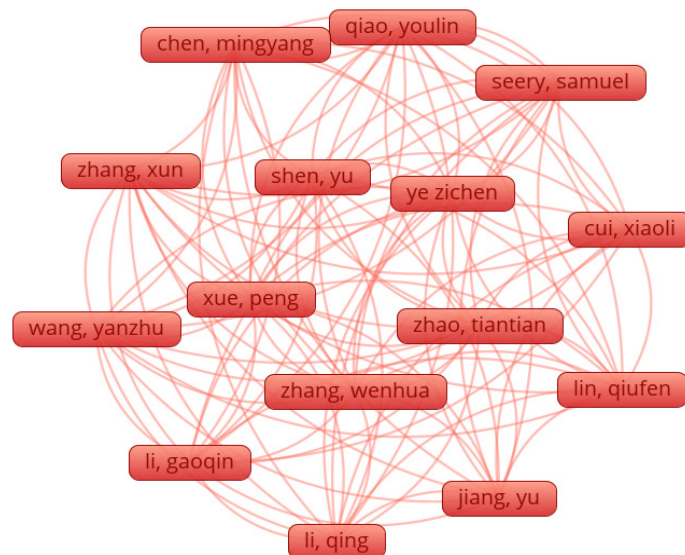


Figure 1. Co-authorship and Authors

Figure 1 shows the co-authorship network among researchers who have worked on studies related to digital competencies in elementary and secondary education teachers. The nodes represent the authors, and the lines connecting them indicate their collaborations in academic publications. The size of each node reflects the author's productivity, and their proximity suggests the frequency of these collaborations.

This analysis highlights the importance of academic collaboration, revealing that a small group of influential researchers is highly connected, indicating a cohesive and active research community. The central authors in this network are key to the dissemination and development of knowledge in this field, setting trends and frequently participating in multicenter projects.

This figure can be used to discuss how academic collaboration affects the development of digital competencies in basic and secondary education and how co-authorship networks can influence the direction of future research in this field.

Analysis of Collaboration Density in Research on Digital Competencies

Figure 2 illustrates the Analysis of Collaboration Density in Research on Digital Competencies, highlighting the co-authorship relationships among researchers in this field.

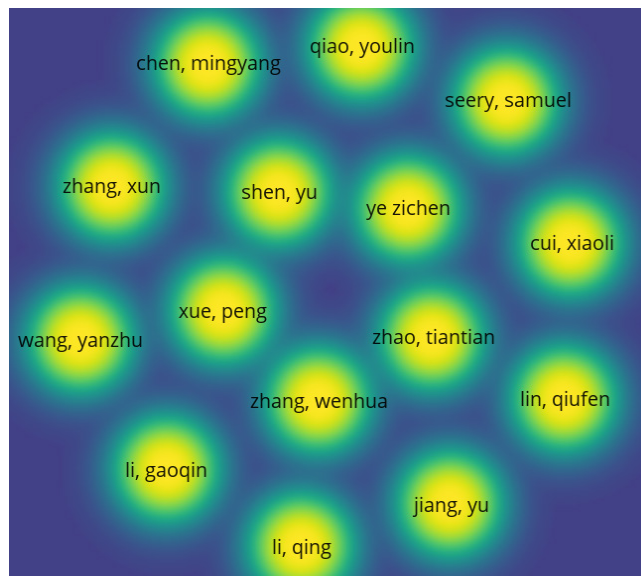


Figure 2. Co-authorship Density Map

Figure 2 shows a density map of co-authorship, visualizing the intensity of collaborations among researchers in the field of digital competencies. The brightest points indicate the authors who have established a greater number of collaborations, positioning them as key figures within the research network.

The figure allows the identification of not only the most prolific authors in terms of publications and collaborations but also the connections between different research groups and the structure of these interactions. The areas of higher density suggest zones of intense collaborative activity, indicating that these authors play a central role in the dissemination of knowledge and the development of trends in the field of digital competencies.

This figure can be used to discuss the importance of collaboration in research on digital competencies, highlighting how key authors and their collaboration networks significantly contribute to the advancement of this field of study. Additionally, it provides a foundation for analyzing how interactions within the academic community can influence the direction and impact of research.

Analysis of Keyword Co-occurrence in Research on Digital Competencies

Figure 3 presents the Co-occurrence Analysis of Keywords in Research on Digital Competencies. This analysis allows for the visualization of the most frequently used keywords in the literature, as well as the connections between them.

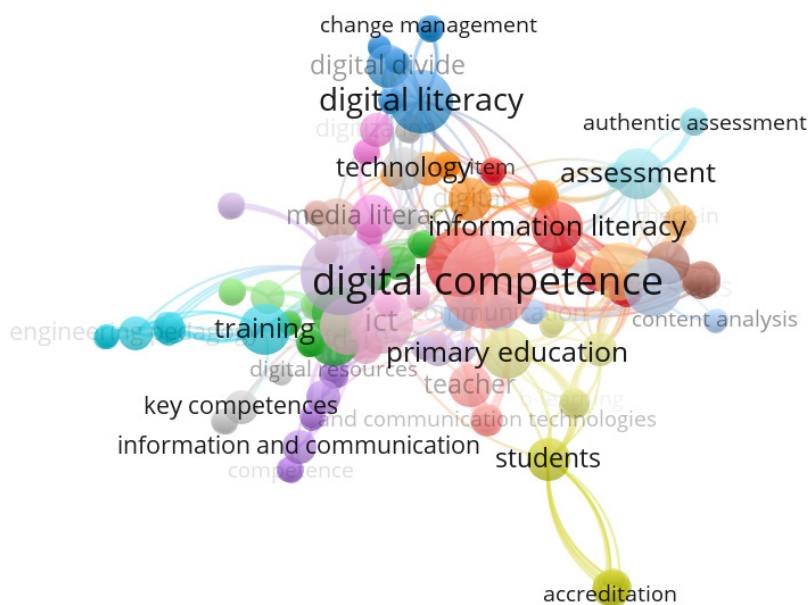


Figure 3. Co-occurrence and keywords

The figure 3 shows the co-occurrence of keywords in the analyzed articles about digital competencies in teachers. The nodes represent specific terms used in the literature, and the connections indicate which keywords appear together in the same documents.

This figure reveals the central and emerging themes in the research, highlighting predominant thematic approaches and their interconnection. For example, the frequent co-occurrence of ‘digital literacy’ and ‘ICT integration’ underscores the relationship between digital literacy and the implementation of ICT in education. This visualization also allows for the identification of topics such as ‘assessment,’ ‘training,’ and ‘media literacy’ as key areas within the study of digital competencies.

This figure is essential for identifying areas of interest and potential gaps in current research. It can be used to discuss how the connections between concepts reflect current trends in the literature and to suggest future directions in the study of digital competencies in education.

Density Map of Keyword Co-occurrence in Research on Digital Competencies

Figure 4 shows the Density Map of Keyword Co-occurrence in Research on Digital Competencies. This map highlights the areas with the highest concentration of related terms, allowing for the visualization of the interrelationships and the intensity with which certain keywords co-appear in studies within the field.

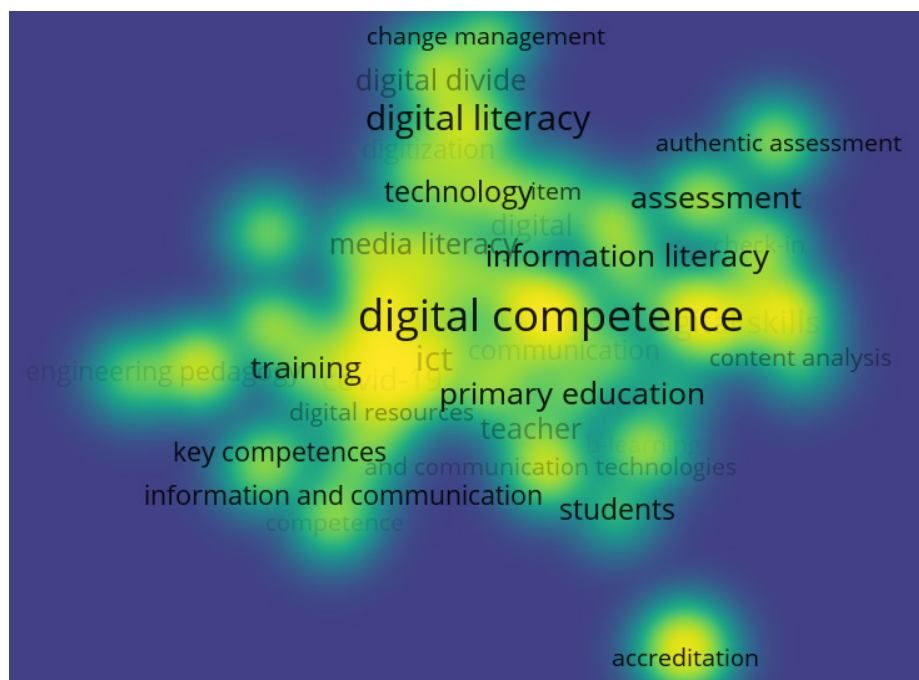


Figure 4. Density map of keyword co-occurrence

Figure 4 shows a density map of keyword co-occurrence in the literature on digital competencies. The terms that most frequently appear together in the analyzed studies are represented by brighter and larger nodes, while less common keywords are represented by less visible nodes.

This visualization reveals the central and emerging topics in the research, highlighting the centrality of terms such as ‘digital competence,’ ‘digital literacy,’ and ‘primary education.’ The figure also provides a comprehensive view of how these topics are interconnected, which is essential for identifying areas of interest and potential future research directions.

This figure can be used to analyze the thematic structure of research on digital competencies, discuss how key terms are interrelated, and suggest areas that may require more attention in future studies. It is also useful for identifying current trends in research and how they relate to each other.

Emerging Thematic Clusters

Digital Competencies in Primary and Secondary Education

Figure 5 presents the Co-occurrence Network of Keywords in the field of Digital Competencies in Basic and Secondary Education.

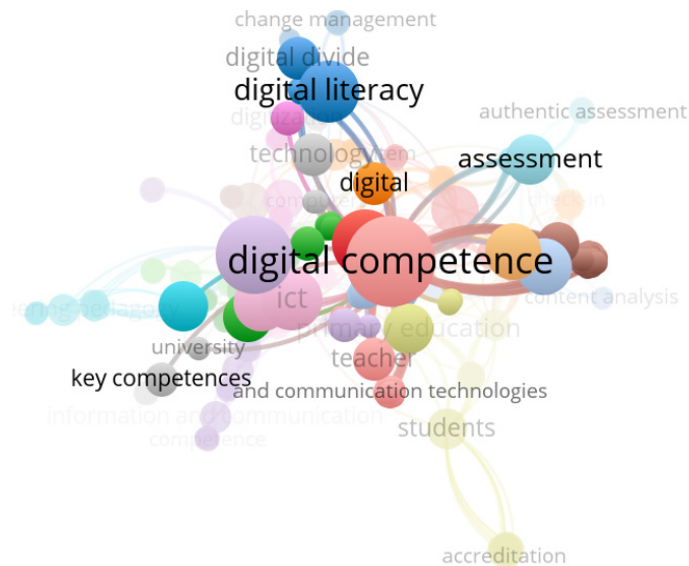


Figure 5. Co-occurrence Network of Keywords

Figure 5 provides an overview of the most relevant topics in the literature on digital competencies. It shows a co-occurrence network of keywords in the literature on digital competencies. Each node represents a keyword, and the lines connecting them indicate the frequency with which these words appear together in the analyzed documents. The size of the nodes reflects the relevance of each term, while the colors group keywords into different thematic clusters. The larger and more connected nodes, such as ‘digital competence’ and ‘digital literacy,’ stand out as central themes in the research, while concepts like ‘assessment,’ ‘technology,’ and ‘primary education’ form coherent research clusters. This visualization reveals the thematic structure of the field, providing a clearer understanding of the focus areas and how different topics are grouped in the study of digital competencies.

Integration of ICT in Primary and Secondary Education

Figures 6 and 7 illustrate the integration of digital literacy in primary and secondary education. Figure 6 highlights the centrality of digital literacy from the early educational stages, while Figure 7 shows the interrelationship between secondary education, digital literacy, ICT, and the role of the teacher in assessment.

Figure 6 illustrates the Integration of Digital Literacy in Primary and Secondary Education.

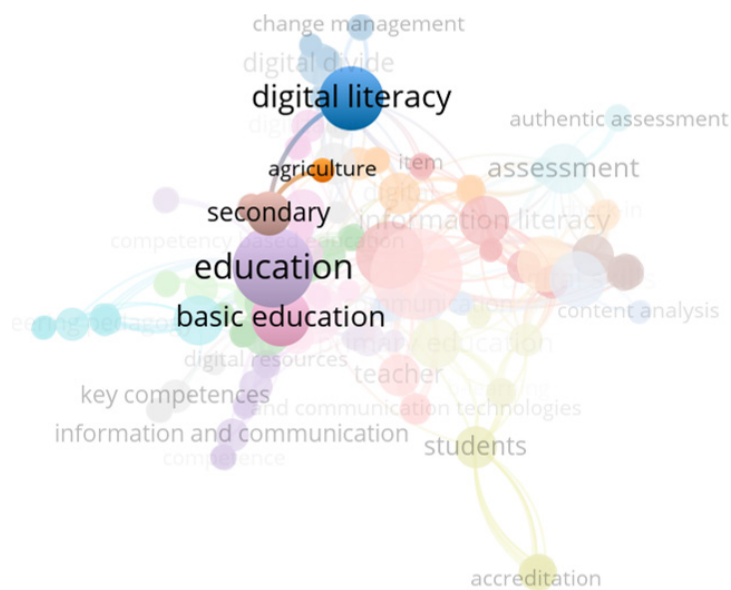


Figure 6. Integration of Digital Literacy in Primary and Secondary Education

Figure 6 highlights “digital literacy” as a central theme in educational research, emphasizing its importance in “basic education” and “secondary education.” The centrality of these terms in the figure indicates a strong interrelationship, suggesting that digital literacy is essential from the earliest educational levels. This figure

is crucial for discussing how digital literacy should be integrated into basic education to prepare students for future challenges in an increasingly digitized environment.

Figure 7 shows the ‘Interrelation of Topics in Education and Digital Literacy’ within the context of the Integration of Digital Competencies in Secondary Education.

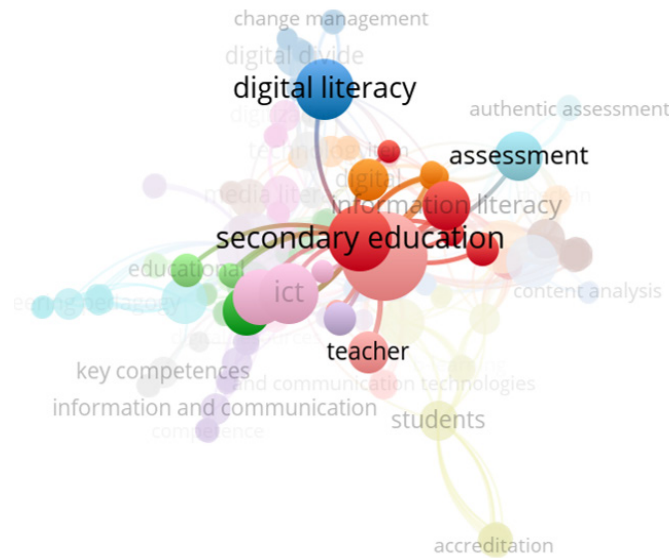


Figure 7. Interrelation of topics in education and digital literacy

Figure 7 is essential for analyzing how secondary education interrelates with digital literacy and ICT. This figure highlights the interconnectedness of topics such as teachers and assessment, emphasizing their importance in implementing digital competencies in secondary education. Through the visualization of these keywords, the figure reveals a broader conceptual framework in educational research, identifying trends, interconnected areas of study, and potential gaps in the literature. The centrality of terms like teacher and assessment underscores their crucial role in integrating technologies and digital literacy strategies in educational contexts.

Impact of the Pandemic on Education

Figures 8 and 9 illustrate how the COVID-19 pandemic has driven the adoption of ‘digital competencies’ in education. Figure 8 highlights the interrelation between ‘digital competence,’ ‘teaching,’ and ‘teacher,’ emphasizing their importance during the crisis. Figure 9 reinforces the relevance of these competencies and ‘digital literacy’ in the transition to online education, highlighting the key role of teachers in this process.

Figure 8 analyzes the ‘Thematic Relationships in Education During the Pandemic,’ highlighting the impact that the health crisis has had on the educational field.

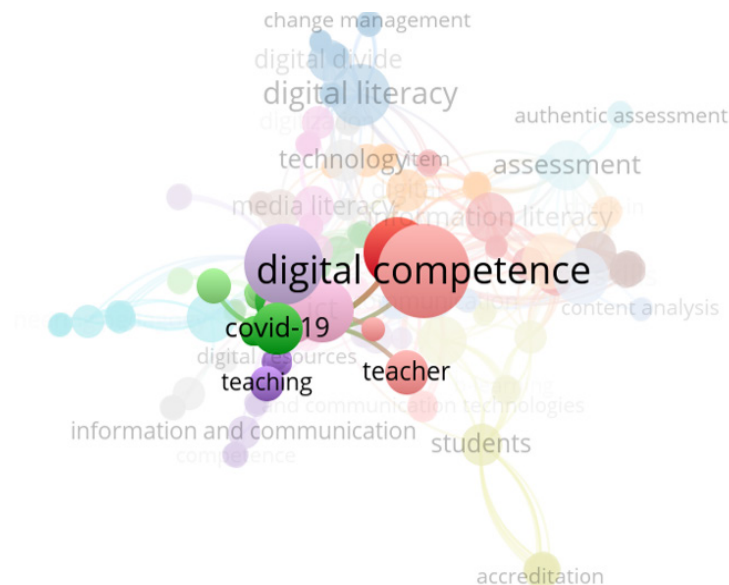


Figure 8. Thematic Relationships in Education During the Pandemic

Figure 8 is crucial for analyzing how the COVID-19 pandemic has accelerated the adoption of ‘digital competence,’ both among teachers and students. This figure shows the interplay between ‘digital competence,’ ‘teaching,’ and ‘teacher,’ highlighting how the pandemic has underscored the importance of training in digital competencies. The visualization emphasizes how these competencies have been essential for education during the pandemic, providing a clear understanding of current trends in research on digital education.

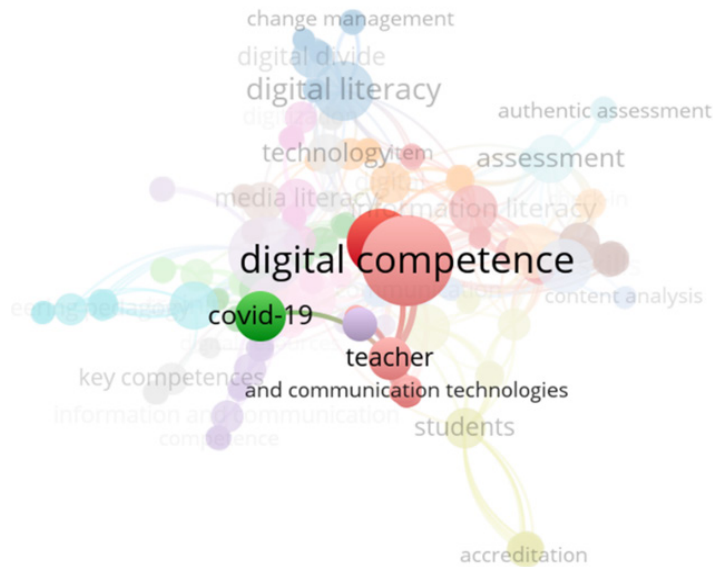


Figure 9. Co-occurrence Map of ‘Digital Competence’ Terms During the COVID-19 Pandemic

Figure 9 underscores the relevance of ‘digital competence’ and ‘digital literacy’ in the educational context, especially under the impact of the ‘COVID-19’ pandemic. The connection between these terms reflects how the pandemic has accelerated the need for digital competencies, highlighting their critical role in the transition to online education and the use of digital technologies. This figure also highlights the importance of ‘teachers’ in this transition, emphasizing the need for training in digital competencies to address the educational challenges that emerged during the pandemic.

Development of Digital Competencies in Teacher Training.

Figure 10 presents the ‘Development of Digital Competencies in Teacher Training.’

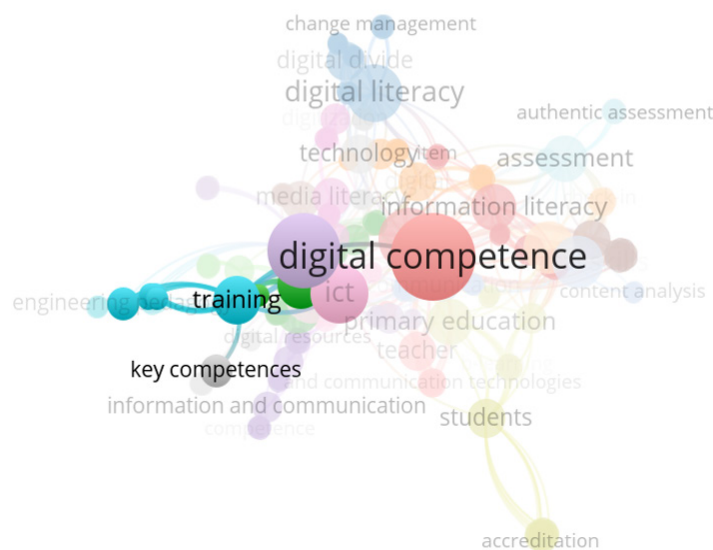


Figure 10. Teacher Training and Key Competences

Figure 10 highlights how ‘digital competence’ is a central theme in the educational literature, showing its interconnection with ‘training’ and ‘key competencies’. This figure emphasizes the importance of teacher

training in the development of ‘digital competence’, which is essential for the effective implementation of technologies in the classroom. The relationship between ‘digital competence’ and ‘ICT’ also underscores the relevance of these competencies in the context of digital technology.

Digital Transformation in Basic Education and e-Learning

The figure 11 explores information literacy in basic education and e-Learning.

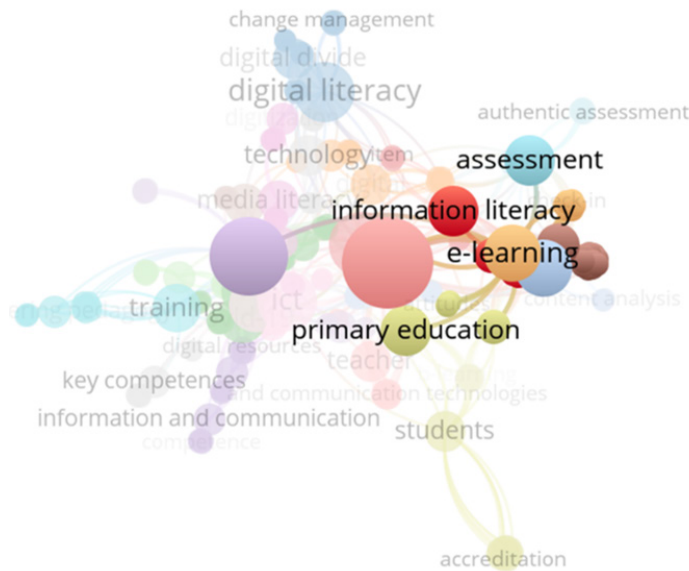


Figure 11. Relationship between Information Literacy, Assessment, and E-Learning

Figure 11 is crucial for understanding how ‘information literacy’ and ‘digital competencies’ relate to ‘assessment’ and ‘e-learning’ in basic and secondary education. This figure highlights the need to integrate information literacy and digital competencies within the educational environment, where assessment plays a critical role in the success of e-learning. The interconnection of these terms in the literature reflects their importance in recent research, emphasizing the relevance of these concepts in the development of educational competencies in the digital age.

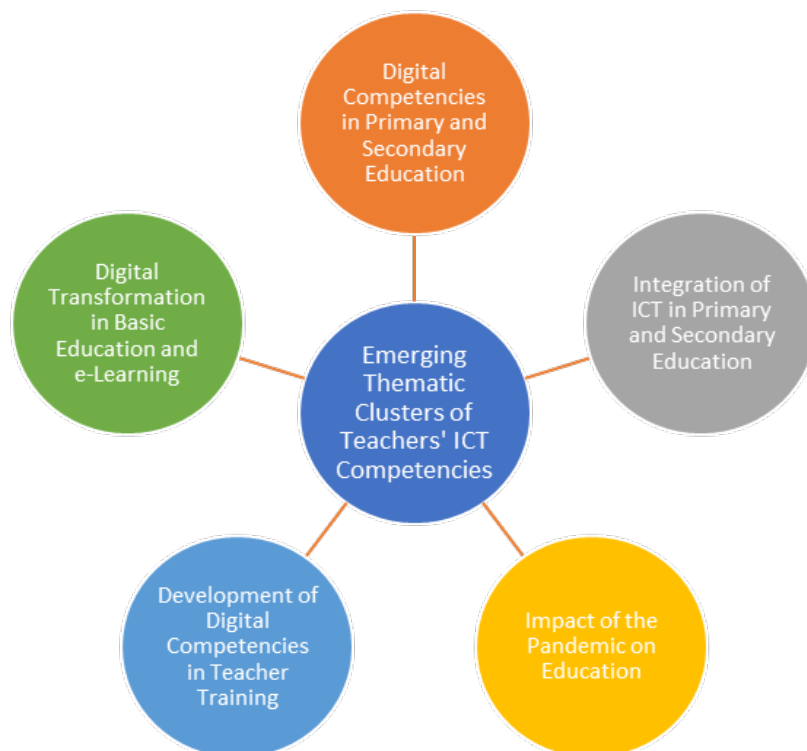


Figure 12. Emerging Thematic Clusters of Teachers' ICT Competencies

Figure 12 illustrates that the development of teachers' digital competencies is fundamental for effectively integrating ICT in primary and secondary education, enabling a more interactive and student-centered teaching approach. This process, accelerated by the COVID-19 pandemic, has highlighted the importance of e-learning and the transition to hybrid models of education. Despite facing challenges such as resistance to change and the need for constant updates, these developments offer significant opportunities to personalize learning and prepare students for a digitized world. Continuous training and assessment of these competencies are essential to enhance teaching practice and ensure quality education in the 21st century.

DISCUSSION

The co-authorship network highlights the strong collaboration among key researchers in the field of digital competencies. This collaboration not only facilitates the advancement of knowledge but also promotes the effective application of these competencies in primary and secondary education. Studies such as those by Alamettälä & Sormunen⁽²⁷⁾ and Ascencio et al.⁽²⁸⁾ emphasize how collaboration networks play a crucial role in knowledge generation, fostering the dissemination of innovative pedagogical practices in digital education. According to Barabási et al.⁽²⁹⁾, the analysis of co-authorship networks allows for a better understanding of the structure and dynamics of scientific collaboration, demonstrating how interactions between authors influence the creation and expansion of academic knowledge.

The analysis of collaboration density reveals focal points of intense academic collaboration, with authors such as Betancur-Chicue et al.⁽³⁰⁾ playing a central role in the development of robust theoretical and methodological frameworks for the study of digital competencies. This type of analysis, such as the one developed by Newman⁽²¹⁾ in his study on academic networks, shows how the high concentration of collaborations in certain nodes suggests that these researchers are not only prolific in terms of academic production but also lead initiatives that influence the formulation of digital education policies.

The co-occurrence of keywords such as “digital literacy” and “ICT integration” highlights central themes in current research. Works like those of Cabellos et al.⁽³¹⁾ address how these digital competencies are essential for modern education, especially in contexts where ICT integration is crucial. Studies such as Chen et al.⁽²⁶⁾ offer a methodological perspective, using co-citation analysis to map the structure and dynamics of research in these fields. The interrelationship of these themes also underscores the importance of media literacy and assessment as key components in the development of effective digital competencies.

The centrality of terms such as ‘digital competence’ and ‘primary education’ emphasizes the need to focus research on how these competencies are developed and implemented from the early educational levels. Studies such as those by Aznar et al.⁽³²⁾ and González et al.⁽³³⁾ have highlighted the importance of early digital literacy to ensure a smooth transition to higher educational levels, where digital competencies are even more critical. The analysis underscores the importance of integrating digital literacy from basic education, preparing students for future digital challenges. Research by Santibáñez et al.⁽³⁴⁾ and Valverde-López & Ureña-Hernández⁽³⁵⁾ has shown how a solid foundation in digital literacy from an early age is crucial for the continuous development of digital competencies throughout secondary education. In this context, the analysis of term centrality, is essential, as it allows for the identification and visualization of key relationships between these educational concepts.^(36,37) This not only reinforces the relevance of these competencies in primary education but also provides a deep understanding of how these terms interconnect and evolve over time, highlighting their impact on educational development.

The thematic structure highlights the relevance of concepts such as ‘assessment’ and ‘technology’ in the development of digital competencies. Research by Frenken et al.⁽³⁸⁾ and Kaarakainen et al.⁽³⁹⁾ has demonstrated that assessment and technology are intrinsically interrelated in the educational context, being crucial for enhancing digital competencies through the implementation of new technologies. In this context, Cobo et al.⁽⁴⁰⁾ emphasize how these relationships can be visualized and structured across different disciplines. Likewise, Jiang et al.⁽⁴¹⁾ underscore the importance of thematic structure in understanding research trends and the evolution of key concepts, reinforcing the relevance of the analyzed concepts.

The interrelation between “secondary education” and “digital literacy” highlights the importance of preparing students to face digital challenges from an early age. Studies such as those by Cuevas-Cajiga & Moreno-Olivos⁽⁴²⁾ and Danilaev & Malivanov⁽⁴³⁾ have emphasized the need to coherently integrate digital literacy into secondary education curricula to ensure that students acquire essential digital competencies for their academic and professional futures. Additionally, the interrelation between “digital competence” and “training” underscores the necessity for teacher training programs focused on digital competencies. Studies like those by Marín et al.⁽⁴⁴⁾ and Hernández et al.⁽⁴⁵⁾ highlight how continuous teacher training is crucial for effectively integrating digital technologies into pedagogical practices. In this regard, Su and Lee⁽⁴⁶⁾ provide a clear view of the interconnection between these educational concepts. Similarly, Gubanov et al.⁽⁴⁷⁾ explored how terminology is structured within a field of study, emphasizing the relevance of the interrelation between specific terms within the terminological network, which is essential for understanding its impact on secondary education and

digital literacy.

Analyses of the impact of the COVID-19 pandemic show how this crisis accelerated the adoption of ‘digital competence’ in education. The interrelation between ‘digital literacy’ and ‘digital competence’ has become essential, especially in the educational context during the pandemic. Research such as that by Cervantes & Gutiérrez⁽⁴⁸⁾ and Llorens et al.⁽⁴⁹⁾ has documented how the pandemic radically transformed educational practices, highlighting the urgent need for ‘digital competence’ and its integration with ‘ICT’ (‘information and communication technologies’) to ensure the continuity of learning during times of crisis. Additionally, the importance of ‘training’ for ‘teachers’ in developing these key competencies is emphasized, thus ensuring effective implementation of technologies in the classroom and preparing them to face emerging educational challenges.

The importance of evaluation in the implementation of ‘digital competencies’ is highlighted by linking it with ‘e-learning.’ Studies such as those by Mejía-Corredor et al.⁽⁵⁰⁾ and Turcios-Peraza & Arguello-Lagos⁽⁵¹⁾ emphasize that proper ‘information literacy’ and accurate ‘assessment’ are essential for the success of ‘e-learning’ strategies. Similarly, the blended learning model, which combines face-to-face and online teaching, reinforces the need for solid ‘digital competencies,’ ensuring their application both in the classroom and in virtual environments, thus improving educational effectiveness.

The analysis of co-authorship networks and the interrelation of terms, as explored by Newman⁽²¹⁾, Barabási⁽²⁹⁾, and Cobo et al.⁽⁴⁰⁾, highlights the importance of understanding the dynamics and thematic structures that guide research in digital competencies. Similarly, studies by Su and Lee⁽⁴⁶⁾ and Gubanov et al.⁽⁴⁷⁾ reinforce the relevance of mapping these interconnections to better understand the evolution and impact of these concepts in education. These perspectives highlight the urgency of a comprehensive approach that includes teacher training, the interrelation of key concepts, and continuous assessment as pillars for addressing educational challenges in the digital age, especially in the post-pandemic context. This approach should encompass the development of teaching competencies, the improvement of academic outcomes, the strengthening of digital skills through the development of computational thinking, and inclusive education in pedagogical practices.^(52,53,54,55,56,57) It is also crucial to integrate innovative methodologies such as flipped learning and the use of artificial intelligence tools.^(58,59) Therefore, it is also recommended to conduct analyses of scientific production, such as bibliometric studies, to explore the current dimensions impacting research on teachers’ digital competencies.⁽⁶⁰⁾

CONCLUSIONS

The bibliometric and trend visualization analysis of digital competencies in basic and secondary education, conducted using VOSviewer, reveals several conclusions that underscore the evolution and importance of this field in contemporary education:

Since 2020, there has been a significant increase in academic production related to digital competencies, especially driven by the COVID-19 pandemic. This event catalyzed the adoption of digital technologies in education, highlighting the urgent need for digital competencies among both teachers and students. This growth in the literature reinforces the relevance of these competencies as an essential component of the educational process in the digital age.

Collaboration between researchers and institutional networks has been crucial for advancing knowledge in digital competencies. Higher education institutions have played critical roles in creating and disseminating knowledge and innovative educational methodologies. These collaborations have enabled the development of effective tools in the educational field, underscoring the importance of academic partnerships in addressing current educational challenges.

Research on digital competencies shows a broad geographical distribution, with significant contributions from countries such as Colombia, Spain, and Mexico. This geographical diversity reflects the global expansion of interest in developing digital competencies, highlighting the need to adapt these competencies to the specific educational and cultural contexts of each region.

Social sciences and education dominate the research areas on digital competencies, emphasizing the need for an interdisciplinary approach to address this topic. The integration of technological approaches in teaching is essential to improve digital literacy and ICT competencies, addressing not only technical skills but also pedagogical, social, and cultural aspects. This multidisciplinary approach is crucial for understanding and addressing the inherent complexity of digital competencies.

Ongoing teacher training in digital competencies is a key element for the effective implementation of technologies in the classroom. Teacher training programs are essential not only for improving educational quality but also for ensuring that students are well-prepared for the challenges of an increasingly digitalized world. Proper teacher training ensures that digital technologies are effectively integrated into the teaching-learning process.

Although English remains the predominant language in academic publications, there is a growing interest in production in Spanish and Portuguese. This linguistic diversity is fundamental for adapting research and educational strategies to local and regional contexts, ensuring that digital competencies are relevant and

applicable in various educational realities.

The findings of this analysis underscore the need to continue strengthening digital competencies in education, with a particular focus on teacher training and academic collaboration. It is essential to develop educational policies that promote digital literacy from basic education, adapting strategies to the cultural and socioeconomic contexts of each region. Additionally, fostering interdisciplinary research and using advanced bibliometric tools to continue mapping and improving the state of the art in digital competencies is recommended.

The co-occurrence analysis of keywords highlights emerging topics such as digital literacy, ICT integration, and competency assessment, which are central to current research. These categories reflect a multidisciplinary approach that combines pedagogical, social, and technological aspects, which is essential for comprehensively addressing digital competencies in education.

The conclusions emphasize the need for interdisciplinary approaches and educational guidelines that promote Digital Competencies in Basic and Secondary Education for teachers, with a particular focus on teacher training and academic collaboration, adapted to different cultural and socioeconomic contexts, especially continuous and effective teacher training to ensure that educators are prepared to integrate ICT into the classroom successfully.

It is recommended to continue using advanced bibliometric tools, such as VOSviewer, to map and analyze emerging trends in this field, which will allow for designing more effective strategies tailored to the current and future needs of digital education.

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Los autores declaran que no existe conflicto de intereses.

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