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DIGITAL SKILLS AND AUTONOMOUS LEARNING IN HIGHER EDUCATION: BIBLIOMETRIC ANALYSIS OF SCIENTIFIC PRODUCTIVITY PATTERNS AND THEMATIC TRENDS (2015-2025)

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ABSTRACT

Self-directed learning and digital skills have become fundamental pillars for addressing the challenges of contemporary higher education. This bibliometric study aims to analyze the scientific production published between 2015 and 2025 in the area of digital skills and self-directed learning in higher education. Scopus and Web of Science were used through search strategies with topics, descriptors, and Boolean operations; the selection of articles was carried out in COVIDENCE and the PRISMA tool with the eligibility criteria; Bibliometrix (RStudio) and VOSviewer were used to generate graphs. Regarding scientific performance, it was found that the 1,018 scientific articles present an annual growth rate (7.18%), but with a decreasing average of citations per year. Meanwhile, the main contributors are ZHANG Y. (authors), BMC Medical Education (source), North West University of South Africa (affiliation), and China (country); The scientific mapping of the co-authorship technique identified one cluster with collaborations, and the co-occurrence of keywords generated eight clusters. Among the limitations identified in the thematic map, a set of areas that require further future research development stood out, especially in those topics classified as niche and emerging.

KEYWORDS: Digital Skills; Self-Directed Learning; Higher Education; Students; Bibliometric Analysis.

1. INTRODUCTION

The increasing integration of digital technologies in higher education has driven a profound transformation in teaching and learning practices. However, strategic management between education and technology is possible as long as students develop digital skills in an appropriate and timely manner. These allow them to access and evaluate information in a critical, communicative and collaborative way in virtual environments under the use of technological tools for learning and solve problems creatively, thus promoting more flexible, personalized training adapted to demands. From the perspective of, "it is one of the basic competencies of the citizen of the twenty-first century and it is also one of the transversal competencies of all universities" (p. 312). (Martínez et al., 2024) (Herrera & Urrejola, 2024; Núñez et al., 2024) (Candia, 2023) Bernate et al. (2021).

According to Tinoco (2023), the current trend for virtual education is based on the use of online learning environments and various platforms, where the student is the protagonist and creator of new learning. For his part, he Tomanguilla et al. (2024) emphasizes that this is a context that demands an education with more autonomous and independent characteristics. In this sense, autonomous learning is understood as the ability to learn by oneself, which implies initiative, commitment and discipline, qualities present in individuals motivated to grow professionally and personally. This type of learning allows them to achieve specific objectives with awareness of the self-direction and self-regulation of the training process (Saucedo et al., 2023).

The research acquires relevance due to the advantages of digital competences for autonomous learning in university education. Previous studies emphasize the contribution to academic success and the development of autonomous and competent individuals in a world in constant technological evolution, acquisition of the ability to make decisions about the learning process itself (Chocarro et al., 2023) (Burris & Burris, 2023), ease in the consolidation of the knowledge necessary for professional performance, adequate use of technological tools synchronously and asynchronously, and contribution to the generation of spaces for training from virtuality. (Ganotice et al., 2023) (Scheel et al., 2022).

Despite the advances, the central problem that motivates the development of this study lies in the limited understanding of how scientific productivity

related to digital competences and autonomous learning has developed in higher education globally during the last decade. Despite the growing interest, there is still a lack of clarity about the main thematic trends, scientific actors and patterns of collaboration that guide this body of research. Based on this problem, the general objective of the bibliometric study is to analyze the scientific production published between 2015 and 2025 in the area of digital competences and autonomous learning in higher education.

This quantitative analysis will allow the identification of productivity patterns, predominant contributors, collaboration networks, as well as the emerging thematic trends that shape knowledge in this discipline. To this end, the following research questions have been formulated that will guide the development, processing and analysis:

1. What is the scientific performance of the literature on digital competences and autonomous learning in higher education between 2015 and 2025?
2. What is the scientific mapping of the networks on the production of digital competences and autonomous learning in higher education between 2015 and 2025?
3. What are the research gaps on the production of digital competences and autonomous learning in higher education between 2015 and 2025?

In summary, the bibliometric study is one of the most effective tools to explore research trends related to the topic in question. Based on this, it aims to offer an updated reference that contributes to strengthening the understanding of how digital skills and autonomous learning have been consolidated as fundamental axes in contemporary higher education during the last decade. In this way, a solid basis will be provided for academic decision-making, and the design of future studies that address the emerging needs of the digital educational environment.

2. METHODOLOGY

Databases Used

For the search for information, Elsevier's Scopus and Clarivate Analytics' Web of Science (WoS) were selected as the main and multidisciplinary bibliographic sources (Vera et al., 2019) most used for bibliometric analysis. (AlRyalat et al., 2019) (Singh et al., 2021) The choice of these databases was valued for being one of the most complete sources for various purposes, since each time it exhaustively covers the scientific and academic literature worldwide, in addition, they are selective both in practice and in theory. (Pranckutė, 2021) (Aksnes y Sivertsen, 2019)

On the other hand, the complete download of the data was carried out on July 14, 2025 in order to avoid biases that may arise from recent updates in the databases, in this way it was guaranteed that the information processed is coherent and uniform for a more accurate and reliable analysis of scientific production. without the influence of changes or additions distort the results of the study.

Search Strategy

In the search for information, strategies were used based mainly on the variables of the theme "Digital Competencies" "Autonomous Learning" from the context of "higher education", which were translated into English to expand the scope of the search and access a greater amount of literature, likewise, common or similar words were used in the bases

given the need to explore different terms that can be used by the authors in their research, ensuring the collection of a wider range of results.

In addition, descriptors such as "TS" were considered in WOS, which allowed searching in fields such as Title, Abstract, Author Keywords and KeyWords Plus®, and in Scopus "TITLE-ABS-KEY" which generated information through the title, abstract and keywords. We also included intersection Boolean operators such as "AND" to join, reduce, and specify, and logical sum or join operators such as "OR" to broaden the search for results that contain several concepts indistinctly. In this sense, the incorporation of the elements required the search in each of the bases. Table 1 below details the combination of the strategies mentioned and then specified in search equations:

Table 1: Search strategies.

Database	Strategies and equations
Scopus	TITLE-ABS-KEY (("digital competences" OR "digital skills" OR "technological competences") AND ("autonomous learning" OR "self-directed learning" OR "independent learning") AND ("higher education" OR "university"))
Web of Science	(((TS=(digital competences)) OR TS=(digital skills)) AND TS=(autonomous learning)) OR TS=(self-directed learning)) AND TS=(higher education)) OR TS=(university)

Source: Prepared by the authors based on the data provided by the databases in the advanced search.

Study Selection

For the selection of the collected studies, COVIDENCE was used, an online systematic review program that offers effective tools to evaluate documents and filter their selection according to eligibility criteria (Table 2). During this process, PRISMA was used to facilitate the rigor and systematization in the choice of literature, this methodology was represented in a flow chart based

on the following levels: (I) Identification, (II) Screening and (III) Inclusion (Figure 1).

The use of COVIDENCE not only optimized the review process, but also ensured greater transparency and reproducibility in the selection of studies, by identifying and eliminating irrelevant documents efficiently, ensuring that only those that meet the established criteria are included, thus contributing to the validity and reliability of the results.

Table 2: Eligibility Criteria: Inclusion and Exclusion.

Inclusion criteria	Exclusion Criteria
Year: 2015 to 2025	Year: before 2015
Population: Higher Education	Population: Primary and secondary education
Document Type: Scientific Articles	Type of document: Essays, memoirs, book chapters, among others
Language: Spanish and English	Language: studies that are not in Spanish or English
Access: Open	Access: Restricted or paid

Source: Authors.

Figure 1 illustrates the selection flow of the scientific literature. In the "Identification" stage, a total of 2,870 documents were recovered, which were distributed between the Scopus (38) and Web of Science (2,832) databases. Of this total, 6 were removed due to duplication. During the "Screening" phase, the titles and abstracts of the papers were reviewed, resulting in the omission of 963 publications that did not fit the subject of the study,

leaving a total of 1,901 papers. This group was subsequently screened using previously established eligibility criteria, which led to the exclusion of 883 articles that did not meet the inclusion indicators, such as year of publication, population studied, type of document, type of access, and language. Finally, in the "Included" stage, 1,018 articles were selected for analysis in bibliometric programs.

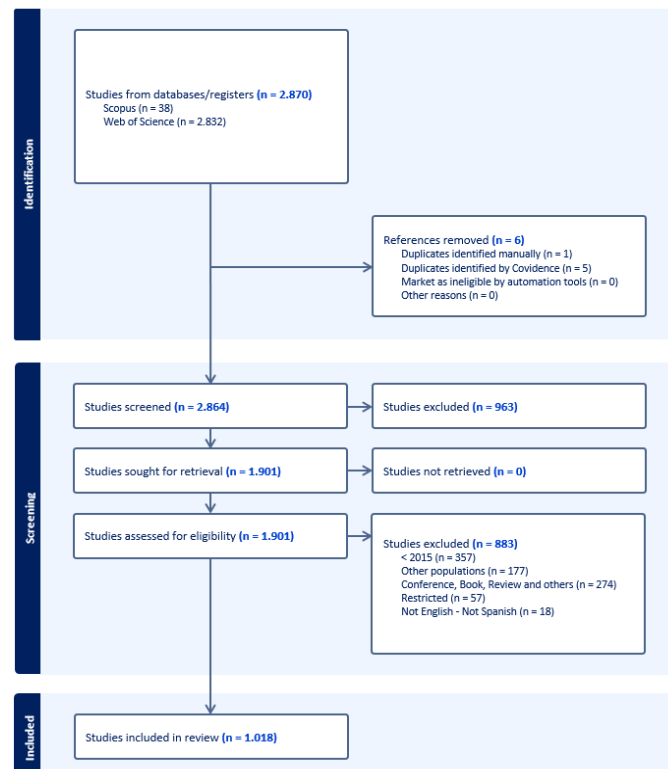


Figure 1: PRISMA Flowchart of the Study Selection Process.

Source: Diagram exported from COVIDENCE.

Data Extraction and Processing

The data corresponding to the 1,018 scientific productions were exported from the COVIDENCE program in CSV format. First, this data was imported individually through the Bibliometrix package (version 4.3.0) in the R programming language (version 4.4.1). Subsequently, after uploading them in the "Import or Load" option, they were exported in Excel format. Then a simultaneous loading and merging of the data was performed using the function "Merge collections in Excel or R format coming from different DBs". In general, the program made it possible to analyze the amount of literature on digital competences and autonomous learning in higher education, in different journals, authors, countries and institutions. This made it easier to generate graphs on performance from both databases. (Zhao & Li, 2023)

At a later stage, VOSviewer, free and open-source software, was used to build and visualize bibliometric networks. This tool made it possible to analyze collaborations and relationships between the selected productions using various techniques and units of analysis. In this way, graphs were developed that reflected the scientific mapping, based on methods such as the analysis of co-authors and co-words. (Oyewola & Dada, 2022)

Bibliometric Methods

In the analysis of the data, two complementary bibliometric methods were implemented: the analysis of scientific performance and the mapping of intellectual production. The first was aimed at measuring the productivity of the thematic area during the last decade through various metrics, both globally and disaggregated by year. Indicators such as the total number of publications, the average number of citations received, as well as the identification of the most prolific authors and the most frequent sources of publication were considered. Likewise, the institutions with the greatest participation and the countries that led the scientific production in the field of study were analyzed. This made it possible to identify temporal trends, impact patterns and the main actors that contribute to the development of the theme.

On the other hand, bibliometric mapping facilitated the approach to the intellectual structure and the existing relationships within the area investigated. To this end, two types of analysis were carried out: the first, through co-authorship analysis, the collaboration networks between the main researchers and working groups were analyzed; the second, the analysis of keyword co-occurrence, made it possible to explore the frequency and combination

of the most relevant terms, which helped to identify predominant thematic lines and to understand the conceptual connections within the field. The

combination of both approaches provided a broad and detailed view of the evolution, scope and interactions in scientific production related to the subject of study.

3. RESULTS

Scientific Performance



Figure 2: General description of the production published in the period 2015 to 2025.

Source: Extracted from Bibliometrix

During the period between 2015 and 2025, the scientific production analyzed highlighted sustained growth and notable thematic diversification. The total number of published documents amounted to 1,018, distributed in 538 different sources, which reflected the wide dispersion and scope of the knowledge produced. In this sense, the annual growth rate was 7.18%, which indicates dynamism in the area of digital skills and autonomous learning in the context of Higher Education. In addition, the average age of the documents was relatively low, standing at 3.81 years, that is, the recent production and updating of scientific content is evident. It also has an impact of publications with an average of 10.11 citations per document, which indicates a considerable level of attention and relevance within the research community.

3,255 keywords provided by the authors were also identified, therefore, it presented a broad and multidisciplinary thematic coverage. On the other hand, the participation of authors and academic collaboration also stood out as relevant elements of the period studied. A total of 3,197 authors participated in the production, of which 181 contributed as sole authors, totaling 189 documents of individual authorship. The overall average was 3.51 co-authors per article, which evidenced a growing trend towards collaborative research. In addition, 18.96% of the works corresponded to international collaborations, an indicator of the degree of openness and cross-border scientific cooperation, which enriched the quality and scope of the published results. These data reflected an active academic community, constantly expanding and strengthened by joint work at a global level.

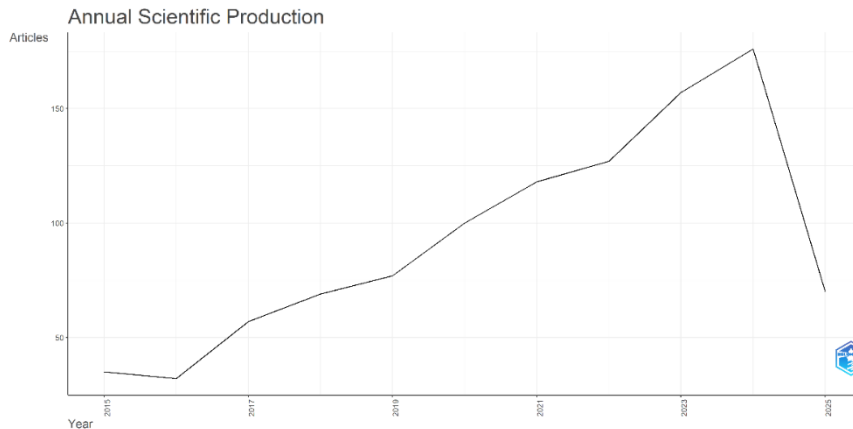


Figure 3: Annual growth in scientific production.

Source: Extracted from Bibliometrix.

Scientific production showed a constant and marked growth, reflected in the annual increase in published articles. In 2015, 35 articles were registered, although in 2016 there was a slight decrease to 32, from 2017 the number rose

progressively to reach 176 in 2024, representing a sustained increase during most of the period. In 2025 alone, a significant decrease was observed with 70 publications, attributed to the end of the period.

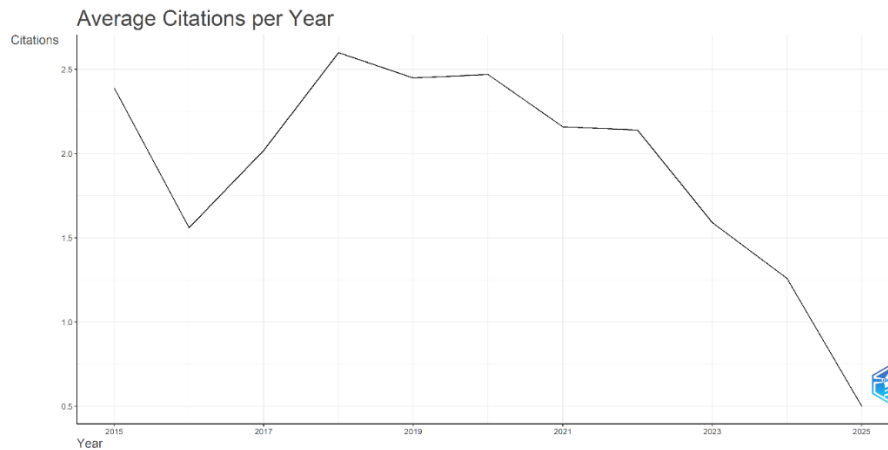


Figure 4: Average citations per year.
Source: Extracted from Bibliometrix

The average number of citations per article showed a decreasing trend as the period progressed, although initially with high values. In 2015, articles received an average of 26.31 total citations each, with an annual average of 2.39, reflecting a strong early impact. From 2016, this figure began to gradually decrease, standing at 15.62 total average citations per article, and remaining between 10 and 20 citations

until 2019. As of 2020, the annual average ranged from 14.81 to 2.52, and by 2025 it dropped to 0.50, in part due to the shorter time window for accumulation and receipt of appointments. Thus, the analysis reveals a growing production, but with less immediate impact in recent years, a phenomenon that is usually observed in the natural evolution of academic citation.

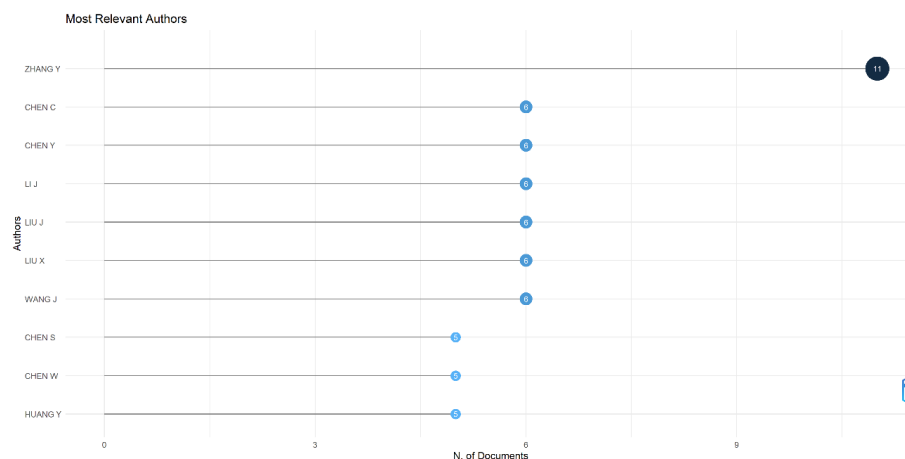


Figure 5: Most relevant authors.
Source: Extracted from Bibliometrix

In the bibliometric analysis, the 10 most relevant authors in terms of scientific production and fractional contribution were identified. ZHANG Y was positioned as the researcher with the highest number of articles, having published 11 papers and with a fractional contribution of 1.85, which reflected his leading role in the generation of knowledge. In

second place, CHEN C stood out with 6 articles and the highest fractional contribution (1.97), evidencing a key role in the co-authorship of significant works. Other authors such as CHEN Y, LI J, LIU J and WANG J maintained a stable production with six publications each, although with variable fractional contributions, which showed differences in the

degree of participation in each study. For its part, CHEN S stood out with five articles, but with the

highest fractional contribution (2.28), underlining its relevance in collective authorship.

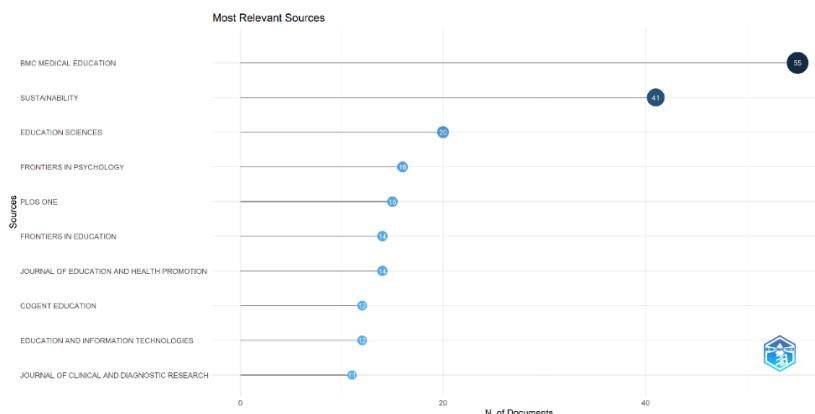


Figure 6: Most relevant sources.
Source: Extracted from Bibliometrix.

The 10 most relevant sources in scientific production were headed by BMC Medical Education, with a total of 55 articles published, making it the leading journal in dissemination within the field. This was followed by Sustainability, which contributed 41 publications, reflecting a prominent interest in sustainability issues applied to education. In third place, Education Sciences registered 20 papers, closely followed by Frontiers in Psychology with 16 articles, and PLOS ONE with 15, the latter a highly prestigious multidisciplinary journal. Frontiers in Education and Journal of Education and

Health Promotion, both with 14 publications each, and Cogent Education and Education and Information Technologies, with 12 articles each, also stood out. Finally, the Journal of Clinical and Diagnostic Research closed this group with 11 publications. This set of sources evidenced a thematic diversity and a marked preference for journals specialized in medical education, sustainability and applied social sciences, configuring a solid center for the dissemination and advancement of knowledge in the areas studied of digital competences and autonomous learning in Higher Education.

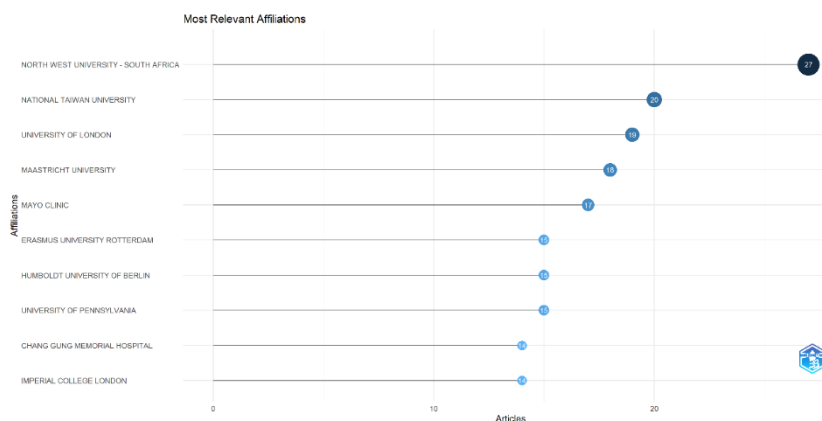


Figure 7: Most relevant affiliations.
Source: Extracted from Bibliometrix.

The institutions with the highest scientific production stood out for their volume and research quality, which reflected their leadership in the global academic field. North West University in South Africa topped the list with 27 publications, showing a leading role in the generation of knowledge. Next, National Taiwan University was found with 20 documents, while the University of London

contributed 19 publications, also consolidating itself as a key player. Other relevant universities included Maastricht University (18), Mayo Clinic (17), as well as Erasmus University Rotterdam and Humboldt University of Berlin, both with 15 publications. The University of Pennsylvania, with an equal number of papers (15), along with Chang Gung Memorial Hospital and Imperial College London, each with 14

papers, rounded out the top ten most productive affiliations. This set of institutions reflected a combination of highly regarded international

universities and clinical research centers, indicating an interdisciplinary and international collaborative ecosystem.

Country Scientific Production

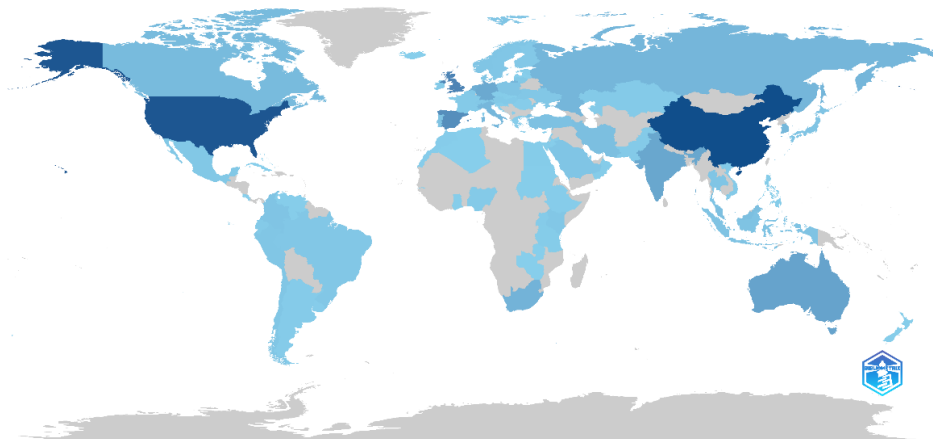


Figure 8: Scientific production by country. Source: Extracted from Bibliometrix.

Scientific production by country showed a clear predominance in China, which led with 348 published documents, followed by the United States with 325 articles. The United Kingdom also had a significant participation with 193 publications, consolidating itself as an important power in research. Spain ranked fourth with 167 documents, reflecting its strong presence in the academic field. Australia and India stood out with 111 and 102 articles respectively, evidencing the growth of their scientific communities. Germany recorded 95 publications, followed by the Netherlands with 84,

showing the relevance of Western Europe in global scientific production. South Africa contributed 69 documents, while Russia closed the group with 61, evidencing the geographical diversity and participation of different continents. This panorama evidenced both the concentration of knowledge in countries with developed economies and the growing contribution of emerging countries and developing regions, and highlights globalization and international collaboration in the scientific generation during the last decade.

Scientific Mapping

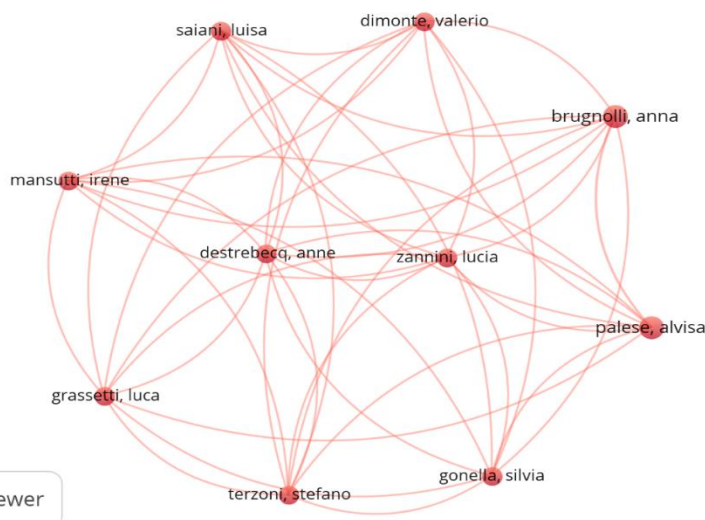


Figure 9: Co-authorship of authors. Source: Extracted from VOSviewer.

Figure 9 of co-authorship illustrated the network of collaboration between the main authors that allowed us to address the understanding of the dynamics. A threshold of 5 was established, in which only 10 of the 3,197 authors met the parameter, showing a connection through collaborative studies with a minimum of 3 citations. In this sense, a highly interconnected group was observed, where all the researchers of the node, such as Lucia Zannini, Anne Destrebecq and Alvisa Palese, established multiple co-authorship links with each other. This dense network of connections evidenced a collaborative

structure, characteristic of consolidated scientific teams that address complex and cross-cutting topics such as digital skills in university environments.

The central position of authors such as Zannini and Destrebecq stands out, who acted as articulating nodes, facilitating integration and communication within the group. The multiple lines that connect researchers, such as Saiani Luisa, Brugnolli Anna, Mansutti Irene and other members of the team, reflected a high frequency of co-authored publications. In short, the configuration of the network suggests the existence of a cohesive community of practice.

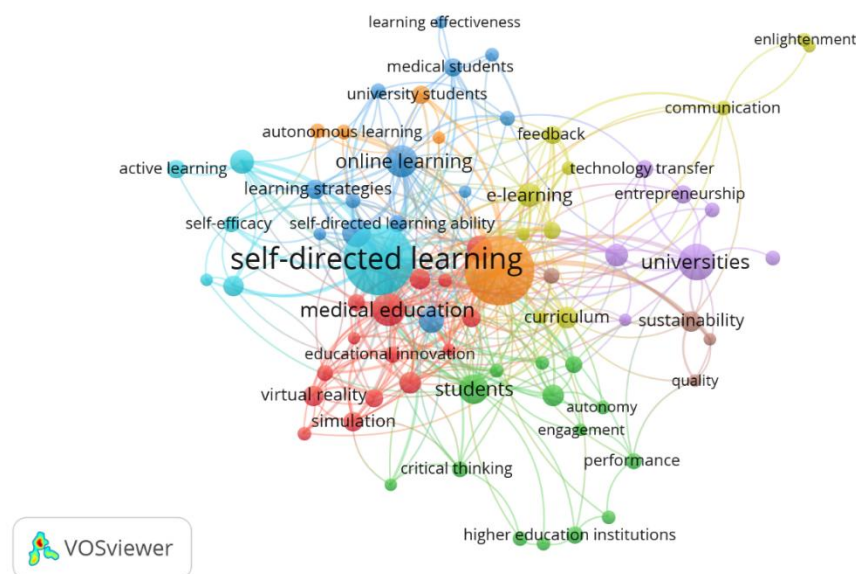


Figure 10: Co-occurrence of author keywords.

Source: Extracted from VOSviewer.

Figure 10 shows co-occurrence as a type of analysis and key words as unity. A minimum threshold of 5 was established, highlighting a total of 3,255 identified words, of these only 89 met the threshold, generating 8 clusters. In this sense, the analysis pointed out several important connections between the different concepts that synthesize the main lines of research on digital competences and autonomous learning in higher education. Each cluster grouped a set related to concepts that reflect the diversity and complexity of the field. Among these, the cluster focused on autonomous learning stands out, which includes terms such as "self-directed learning", "self-efficacy" and "learning strategies", evidencing the importance of autonomy and strategies for independent learning in university contexts.

Another relevant cluster was related to medical education and the use of simulation, where concepts such as "medical education", "virtual reality" and

"simulation" expressed a strong orientation towards technological innovation applied to professional health training. Likewise, a group focused on online learning and self-efficacy was identified, in which terms such as "online learning" and "autonomous learning" highlight the growing incorporation of virtual environments to enhance the autonomous capacity of university students.

Likewise, other clusters addressed cross-cutting issues such as curriculum, critical thinking and performance, integrating terms related to curricular structuring and the evaluation of autonomous learning. In addition, a cluster dedicated to educational innovation and sustainability was distinguished, which highlighted the relationship between the transformation of educational models and quality in higher education. In another group, the link between universities, technology transfer and entrepreneurship reflected the institutional role in promoting digital skills and connecting with the

economic and social environment. Finally, the network included clusters associated with the evaluation and feedback of training processes, and with the motivational and commitment aspects fundamental for the full development of autonomy

and digital competences in higher education. Together, these clusters revealed an integrated and multidimensional vision of current research in the area, where technologies, pedagogies, and institutional contexts converge.

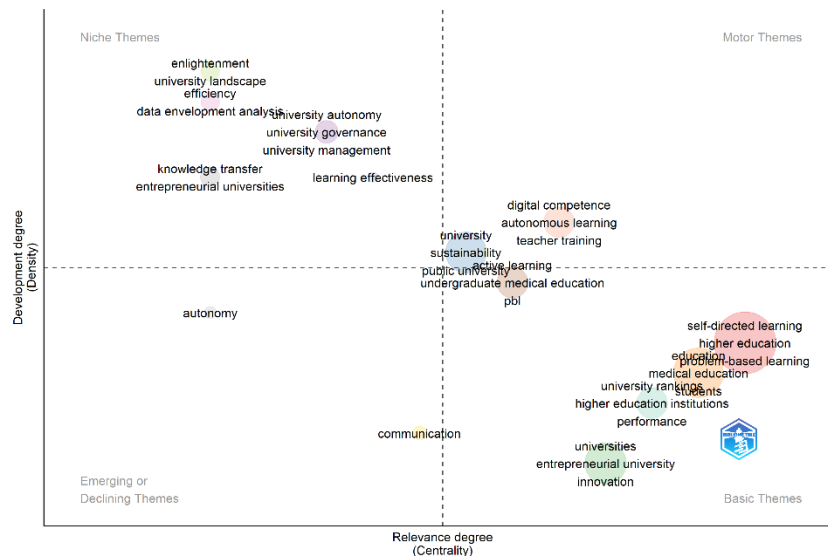


Figure 11: Thematic map of author's keywords.

Source: Extracted from Bibliometrix

The results derived from Figure 11 are presented below, which contextualizes the thematic map of author's keywords in the field of digital competences and autonomous learning in higher education. On the one hand, in the upper right area are the *motor themes*, characterized by a high degree of development (density) and a high centrality (relevance). These topics were at the heart of the research because they are fundamental and constantly expanding. In this quadrant, terms such as "digital competence", "autonomous learning", "teacher training", "medical education", and "pbl" (problem-based learning) stood out. Their location indicates that they represent consolidated lines of research that articulate and connect different areas, being a point of reference for new theoretical developments and practical applications. In addition, they are booming, which shows their relevance in the recent academic literature on higher education.

In the lower right, the *basic topics* have a high centrality, but a lower degree of internal development. In this quadrant, keywords such as "self-directed learning", "higher education", "education", "competency-based learning", "university", "ranking", "institutions", "performance", "universities", "entrepreneurial university" and "innovation" are established. These terms form the conceptual and structural basis of the research, reflecting the permanent interest in improving

educational processes and competencies at this professional level.

On the other hand, in the lower left quadrant are the *emerging or decadent themes*, those with low centrality and low density. These issues are in the early stages of development, gaining recent attention, or are losing relevance. In this case, "autonomy" and "communication" are the representative concepts, suggesting areas with less articulation in the literature or with potential for future growth if integrated with other central thematic cores.

Finally, in the upper left are *niche themes*, which have a high level of density, but low centrality, reflecting independent and specialized developments. In this space we find terms such as "enlightenment", "university landscape", "efficiency", "data envelopment analysis", "university autonomy", "university governance", "university management", "knowledge transfer", "entrepreneurial universities" and "learning effectiveness". These topics, although well developed internally, are not directly integrated with the main topics of the field and are usually addressed by more specific communities of researchers.

Overall, the map highlights the relevance of digital skills and autonomous learning in higher education, underscoring both consolidated trends and areas of opportunity for future research.

4. DISCUSSION

This bibliometric study provides a comprehensive view of the evolution and current state of the trend and patterns of scientific production linked to digital competences and autonomous learning in higher education, addressing the questions raised.

Regarding scientific performance, the results show a sustained and dynamic growth in publications during the last decade with an average annual increase of 7.18%. In this sense, the knowledge base is broad and multidisciplinary, with significant author participation and international collaboration, factors that strengthen the quality and scope of research in this field. However, the impact on citations has progressively decreased in recent years, a common phenomenon that stands out for the recent nature of some contributions and the slow accumulation of academic recognition in newer productions.

It also highlights the central role of certain institutions, sources, authors and contributing countries that lead scientific production, opening the opportunity to foster more inclusive collaborations that integrate emerging regions and diverse educational realities. This integration contributes to enriching the global perspective and addressing challenges such as the digital divide and continuous training, which are key to the effectiveness and sustainability of digital skills in university contexts.

Regarding scientific mapping, the analysis of collaboration and co-authorship networks revealed consolidated communities of practice, with key researchers acting as articulating nodes for the integration of knowledge and global academic cooperation. The thematic networks identified through the co-occurrence of keywords showed a diversified field of study, ranging from autonomy in learning and digital competences, to technological innovations such as virtual medical education and educational sustainability. This thematic mapping also made it possible to distinguish consolidated central lines and emerging or specialized areas, which facilitates understanding the structure, development and frontiers of current knowledge on these topics.

The study also identified clear research gaps and opportunities to deepen scientific knowledge. Among these, areas with low centrality and density on the thematic map stand out, such as communication and some aspects of autonomy, which can benefit from additional research to strengthen their integration with motor themes in

the field. Likewise, the need to expand studies that directly link digital skills with concrete results in academic performance and educational equity was detected, as well as research that explores in greater detail the impact of digital divides and training strategies for teachers and students. The insufficient attention to some institutional and contextual areas also suggests the convenience of undertaking more contextualized and multisectoral studies.

Together, these contributions confirm the consolidation of digital skills and autonomous learning as cross-cutting axes in contemporary higher education, while warning about the relevance of strengthening interdisciplinary and international cooperation to boost educational innovations and expand the social impact of the knowledge generated.

5. CONCLUSIONS

The bibliometric analysis carried out on the scientific production of digital competences and autonomous learning in higher education during the period 2015-2025 revealed a notable and sustained growth in research (7.18%), but with a decreasing average number of citations per article. On the other hand, among the main and leading contributors of the research actors, ZHANG Y. (authors), BMC Medical Education (source), North West University of South Africa (affiliation) and China (country) were identified.

The scientific mapping made it possible to identify consolidated communities of researchers that acted as key nodes for the generation and dissemination of knowledge, as well as consolidated and emerging thematic lines that shape the current state of the area. The existence of thematic focuses linked to autonomous learning, educational innovation and technological application in vocational training underlines the ability of the field to adapt to contemporary dynamics and respond to the challenges arising from digitalisation.

Despite these advances, the study also highlights relevant gaps, such as the underexploitation of issues related to communication and autonomy, as well as the limited production that links digital skills with concrete results in equity and academic performance. The identification of these areas of opportunity opens a clear path for future research that delves into these aspects and contributes to a more comprehensive and equitable development of digital higher education.

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