

Trends, Scientific Productivity, And New Themes In Digital Literacy Training For Vocational Teachers: A Bibliometric Analysis

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Abstract

For 21st-century learning demands, yet most globally available digital competence frameworks for teachers are designed for general education rather than technical and vocational education and training (TVET) specifically. This study aims to map the trends, productivity, thematic structure, and research gaps in the scientific literature on digital literacy within the context of vocational teacher training, serving as a preliminary study for a subsequent empirical training-needs analysis. Data were collected from the Scopus database in February 2026 using a combination of three keyword clusters (digital literacy/competence, training, and vocational teachers/education), limited to journal articles and conference proceedings published between 2023 and 2025, yielding 216 documents. The data were analyzed using VOSviewer through co-authorship analysis (author, organization, country), keyword co-occurrence analysis (network, overlay, density), and co-citation analysis. The results show that the number of publications increased sharply from 22 documents (2023) to 125 documents (2025), yet scientific collaboration patterns at the author, institutional, and country levels remain highly fragmented. Keyword analysis reveals that themes related to teacher training and digital competence form a considerably smaller and less dense cluster compared to themes related to vocational student learning, despite the availability of an established conceptual framework such as DigCompEdu. These findings indicate a clear research gap in empirical studies on the digital literacy training

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needs of vocational teachers, providing the foundation for further research based on a competency discrepancy analysis.

Keywords: digital literacy; teacher training; vocational education; bibliometric analysis; VOSviewer

INTRODUCTION

The 21st century demands that the education system equip students with a set of skills that are much different from the demands of previous times (Benke & Rachwał, 2022). The 21st century skills framework formulated by Trilling and Fadel affirms that digital literacy, alongside critical thinking, communication, and collaboration skills, has become one of the main pillars that students must master in order to be able to survive and contribute to an all-connected knowledge society (Trilling & Fadel, 2009). This demand applies to all levels and paths of education, including vocational education, which specifically has a mandate to prepare its graduates to be ready to enter the world of work, which is now almost entirely intersected with digital technology. These technologies range from industrial automation, digital-based management systems, to work tools that require technological proficiency as a basic prerequisite (Diao & Qu, 2024; Kuznietsov & Dobroskok, 2026).

However, the readiness of vocational learners to face these demands ultimately depends on the readiness of their teachers first (Deschênes & Dionne, 2024). Teachers cannot teach skills that they do not master themselves. In the context of digital literacy, this means that vocational teachers are required to have adequate digital competencies before they can effectively guide learners (Yang & Wu, 2024). Realizing this urgency, a number of international institutions have developed a framework of reference to define and measure teachers' digital competence, including *the ICT Competency Framework for Teachers* prepared by UNESCO as a guide to pre-service and in-service training for teachers at all levels (UNESCO, 2022) and *the European Framework for the Digital Competence of Educators* (DigCompEdu) which outlines teachers' digital competence into six areas of professional and pedagogical competence in more detail (Centre & Commission, 2022). These two frameworks have been widely adopted and adapted by various countries as a reference in designing digital literacy training policies and programs for teachers. The problem is that the two reference frameworks, like the majority of digital teacher competency frameworks circulating globally, are designed for the context of education in general,

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not specifically for *technical and vocational education and training* (TVET). The database of digital competency frameworks compiled by UNESCO-UNEVOC, a special body of UNESCO that oversees vocational education issues globally, even notes that of the many digital teacher competency frameworks that have been developed by various countries and institutions, only one framework is explicitly designed specifically for TVET teachers and instructors, namely *the Digital Teaching Professional Framework* developed by the *Education and Training Foundation* in the United Kingdom (UNESCO-UNEVOC, 2021). The gap in the availability of a reference framework that is appropriate to this context is an early signal that the need for digital literacy training for vocational teachers has the potential to have different characteristics from the needs of teachers in the general education pathway, so it cannot be fully assumed to be fulfilled just by adopting the general frame of reference.

The issue of digital readiness of vocational teachers is not a new issue in the education discourse, but the explosion of attention to it has only really been felt in recent years. As will be shown in more detail in the results of this study, the number of scientific publications that discuss the intersection between digital literacy, training, and vocational education increased significantly during the period 2023 to 2025. This is an indication that the global academic community is actively responding to the demands of digital transformation in the vocational education sector. A number of previous studies have documented various aspects of this phenomenon, ranging from the application of online and virtual reality-based learning in vocational environments, digital transformation in the curriculum and *apprenticeship* learning system, to the challenges of implementing technology in the context of Industry 4.0. These studies collectively enrich the understanding of how digital technology is changing the face of vocational education in general. However, most of the attention in the literature wave seems to be directed more towards the learning process from the perspective of learners and institutions, rather than on the readiness and need for training for the teachers themselves (Chen, 2024; Xin et al., 2024). This condition raises a fundamental question: to what extent has the existing scientific literature so far really answered the specific needs of vocational teachers in developing their digital literacy, and not just being part of the larger discourse on the digitalization of vocational education in general? This question underlies the need for a systematic mapping of the structure, trends, and direction of development of the scientific literature on this topic, as a first step before empirical research on the need for digital literacy training for vocational teachers can be designed in a more targeted and evidence-based manner.



To answer these questions systematically and measurably, an approach is needed that is able to map the scientific literature landscape as a whole, rather than simply relying on a review of narrative literature that is vulnerable to being selective and subjective. Bibliometric analysis offers such an approach, because of its ability to systematically parse large volumes of literature and visualize the patterns of trends, collaborations, and thematic structures contained in them (Donthu et al., 2021). Unfortunately, a preliminary search of the available literature shows that bibliometric studies that specifically map the intersection between digital literacy, training, and vocational education are still very limited, and to the extent of the search, there have been no bibliometric studies that explicitly focus their mapping on the need for digital literacy training for vocational teachers as the main object of study. This gap at the methodological level goes hand in hand with the emptiness at the substantive level that has been mentioned earlier, namely the limited digital competency reference framework designed specifically for the TVET context. The combination of the lack of systematic mapping of the existing literature and the limited contextual framework of reference is the research *gap* that underlies this research: there is no clear and data-based picture of the extent, direction, and at what point research on digital literacy training for vocational teachers has developed, so that the direction of further empirical research on this topic still has to be pioneered without an adequate literature roadmap as a foothold.

Departing from this gap, this research offers novelty at two levels at once. First, at the substantive level, this research is one of the initial efforts to specifically map the structure and trends of research on the intersection of digital literacy, training, and vocational teachers, which is a slice of topics that have been more often discussed separately, both as part of the study of digital literacy in general, the study of vocational education in general, and the study of teacher professional development in general, without ever being really put together as a separate mapping object. Second, at the functional level, this research is positioned not as a stand-alone study, but as a preliminary study whose results directly become an argumentative and conceptual basis for further research on the empirical analysis of digital literacy training needs for vocational teachers. Thus, the novelty of this research lies not only in what is mapped, but also in how the results of the mapping are deliberately designed to bridge the identified conceptual gaps towards more contextual and applicative empirical research.

Based on the background, problem identification, and research gaps that have been described, the main problem formulation that is the focus of this research is: *how to analyze the needs of digital literacy training for vocational teachers in realizing 21st century learning?* To



answer the formulation of these problems, this bibliometric research is specifically directed to answer the following four research *questions*:

1. How has the trend of research publications on digital literacy in vocational teacher training developed from year to year?
2. How are patterns of productivity and scientific collaboration formed on this topic, both at the author, institutional, and state levels?
3. What themes dominate research on this topic, and what themes show emerging *themes*?
4. What research gaps can be identified from the existing literature structure as a basis for further empirical research on the need for digital literacy training for vocational teachers?

Based on the formulation of the problem, this study aims to map trends, productivity, thematic structure, and research gaps in the scientific literature on digital literacy in the context of vocational teacher training, as an evidence-based foundation for the formulation of further digital literacy training needs for vocational teachers. Theoretically, this research is expected to enrich the treasure of bibliometric studies in the field of vocational education, especially by presenting a literature map that specifically focuses on the intersection between digital literacy, training, and vocational teachers that has not been widely mapped separately. Practically, the results of this study are expected to be a reference for vocational education policy makers, teacher training program organizers, and advanced researchers in designing research programs and instruments that are more targeted and based on real needs in the field, as well as becoming a conceptual and argumentative foundation for further research on the empirical analysis of digital literacy training needs for vocational teachers.

METHODS

Research Design

This study uses a bibliometric approach to map trends, productivity, thematic structure, and research gaps in the field of digital literacy study in the context of vocational education teacher training. Bibliometric analysis was chosen because of its ability to systematically and quantify the volume of large volumes of scientific literature, as well as visualize patterns of relationships between bibliographic elements, both authors, institutions, countries, and keywords that are difficult to capture through a review of conventional narrative literature (Donthu et al., 2021; Fathurochman, 2025; Liu & Xu, 2025). This research is specifically directed to answer four research *questions*, namely: (1) how the trend of research publications on this



topic develops from year to year; (2) how patterns of productivity and scientific collaboration are formed, both at the author, institutional, and state levels; (3) what themes dominate and what themes show emerging *themes*; and (4) what research gaps can be identified as a basis for further empirical research.

Data Collection Process

The data collection process begins with the preparation of search keywords which are arranged into three clusters of interrelated terms, then combined using the Boolean AND operator so that the search results are really on the third slice of the cluster, not just alluding to one of them. The first cluster contains terms related to digital literacy and competence in general, the second cluster contains terms related to training and professional development, and the third cluster contains terms related to teachers and vocational education. The complete keywords used are as follows:

("digital literacy" OR "digital competence" OR "digital skills" OR "digital capability" OR "digital fluency" OR "digital creativity" OR "digital media literacy" OR "ICT literacy" OR "digital transformation" OR "digital technology") AND ("training" OR "professional development" OR "teacher training" OR "in-service training" OR "capacity building") AND ("vocational teacher*" OR "vocational education" OR "vocational training" OR "TVET" OR "VET" OR "technical and vocational education")

The data search was conducted in February 2026 through the Scopus database, which was chosen for its extensive journal coverage and strict curation and quality control processes for the sources it indexed, making it one of the most widely used bibliometric databases in quantitative science research (Baas et al., 2020). The search was limited to the type of journal document and conference proceedings, with keywords searched specifically in the title section of *the* document, as well as the range of year of publication 2023 to 2025. The search restriction on the title of the document was chosen to ensure that the research topic was truly the main focus of the article being netted, rather than simply being mentioned at a glance in the content section. The search results with these criteria yielded 216 relevant documents.

All 216 documents were downloaded in CSV (*comma-separated values*) file format with metadata that included the title, author, institutional affiliation, abstract, keyword, and bibliography of each document. No further manual screening of the 216 documents was carried out, considering that the search criteria that had been strictly applied in the early stages



(restrictions on document titles and the combination of three keyword clusters through the Boolean AND operator) were considered sufficient to ensure the overall relevance of the documents netted to the research topic.

Data Analysis Procedure

The data that has been obtained in the form of CSV files is then processed using the VOSviewer application, a software specifically developed to construct and visualize bibliometric networks in the form of science maps (Jan & Ludo, 2010). VOSviewer was chosen for its ability to efficiently process large amounts of data and present them in a visual form that facilitates the interpretation of patterns of relationships between bibliographic elements. This study uses three types of analysis in VOSviewer, each of which is directed to answer a different research question, as summarized in Table 1.

Table 1. Types of VOSviewer analysis and their relationship to research questions

Types of Analysis	Unit of Analysis	Threshold	Reply
Co-authorship	Author	Minimum of 2 documents per author	RQ2
Co-authorship	Organization	Minimum of 2 documents per institution	RQ2
Co-authorship	Country	Minimum of 5 documents per country	RQ2
Co-occurrence	All Keywords	Minimum of 5 pop-ups per keyword	RQ3
Co-citation	Cited References	Minimum of 3 joint citations per reference	RQ3/RQ4 Supporters

The *co-authorship analysis* was used to map the pattern of scientific collaboration at the three levels of the analysis unit, namely authors, institutions, and countries, in order to identify the structure of productivity and cooperation networks in this field of study. Co-occurrence analysis of all *keywords* is used to map the thematic structure of the research, with three forms of visualization complementing each other: *network visualization* to identify clusters of themes based on keywords that often appear simultaneously (Delecroix & Eppstein, 2004), *overlay visualization* to explore the time dimension and trends of emerging themes, as well as *density visualization* to identify areas of topic that have been saturated compared to areas that are still



rarely explored (Jan & Ludo, 2010). In addition, *co-citation* analysis at the cited *reference* level was used to search for reference works that were consistently cited together by the literature in the data corpus, as an indication of the theoretical foundation underlying this field of study. Annual publication trend data and the productivity of sources (journals/proceedings) used to answer RQ1 were obtained separately through the *Analyze Search Results feature* on the Scopus platform

RESULTS AND DISCUSSION

This bibliometric analysis is based on 216 documents obtained from the Scopus database through the application of keywords that include three term clusters, namely digital literacy/competence, training, and teachers/vocational education, with restrictions on journals and proceedings published in the 2023–2025 range. The data obtained is then processed using the VOSviewer application to map collaboration patterns, theme distribution, and research development directions in this field.

Research Publication Trends

The data collected from 216 documents shows an unusual growth trajectory for a relatively specific research topic. In 2023, the number of publications discussing the intersection between digital literacy, training, and vocational teachers will only reach 22 documents. This number is reasonable for a topic that is still on the fringes of academic attention. But a year later, the figure jumped to 69 documents, and in 2025 it jumped again to 125 documents. If read as a growth line, this curve is not just up, but up with a slope that continues to grow sharply from year to year. This pattern, in bibliometric parlance, is known as exponential growth in the early phases of a field of study, as first described by Price in his classic study of the dynamics of the growth of the scientific literature, which states that the rate of growth of a scientific field tends to be directly proportional to the magnitude that has been achieved before, so that the larger a field, the faster it grows (de Solla Price, 1963). This pattern of growth has been widely reconfirmed by bibliometric studies in various other disciplines, which have found that sharp spikes in publication over a short period of time are often a sign that a topic is moving from a fringe position to mainstream attention in its parent discipline (Bornmann & Mutz, 2014).



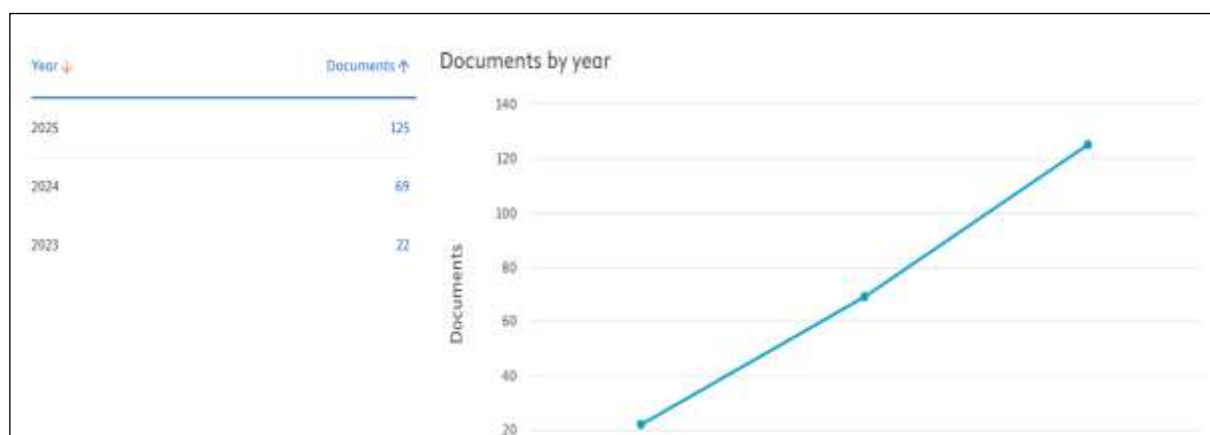


Figure 1. Trend in the number of publications in 2023–2025

(Source: Scopus, processed by the author)

There is one thing to note carefully before this surge is read too optimistically. The data collection process was carried out in February 2026, which means that the count of 125 documents in 2025 actually reflects the achievements of the entire calendar year, not an unfinished piece of time. Nevertheless, the scope of the Scopus database is dynamic, metadata is constantly updated, backfiles are constantly being added, and document indexation has a lag between the official publication date of an article and the date it actually appears and can be searched in the database, so the same search can result in a different corpus if rerun at different times (Baas et al., 2020). In other words, it is possible that the 125 figure in 2025 is not yet fully final, and by the time this data is retraced a few months from now, the number could increase again. A characteristic that bibliometric researchers are indeed commonly found in the most recent year span of an observation period (El Majjaoui et al., 2026). This reinforces, not weakens, the impression that the trends captured in this study are ongoing trends, not trends that have been completed and can be read from afar.

When attention is shifted from the total number of publications to the place where they are published, the picture that emerges is slightly different from the impression of smooth growth. The five sources with the most contributions, including *the Journal of Technical Education and Training*, *Vocation, Technology and Education*, *the International Journal of Learning, Teaching and Educational Research*, *Education Sciences*, and *AIP Conference Proceedings*, show a growth pattern that is not uniform with each other. *The Journal of Technical Education and Training* grew most convincingly, from two papers in 2023 to seven papers in 2025, as if it were building its position as the main home for this study. But *Vocation, Technology and Education*

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took the opposite path: it had been the most productive source in 2024 with five papers, then declined to four papers a year later. The other three sources moved flatter, with *the International Journal of Learning, Teaching and Educational Research* growing slowly and the other two barely moving from one to two papers per year.

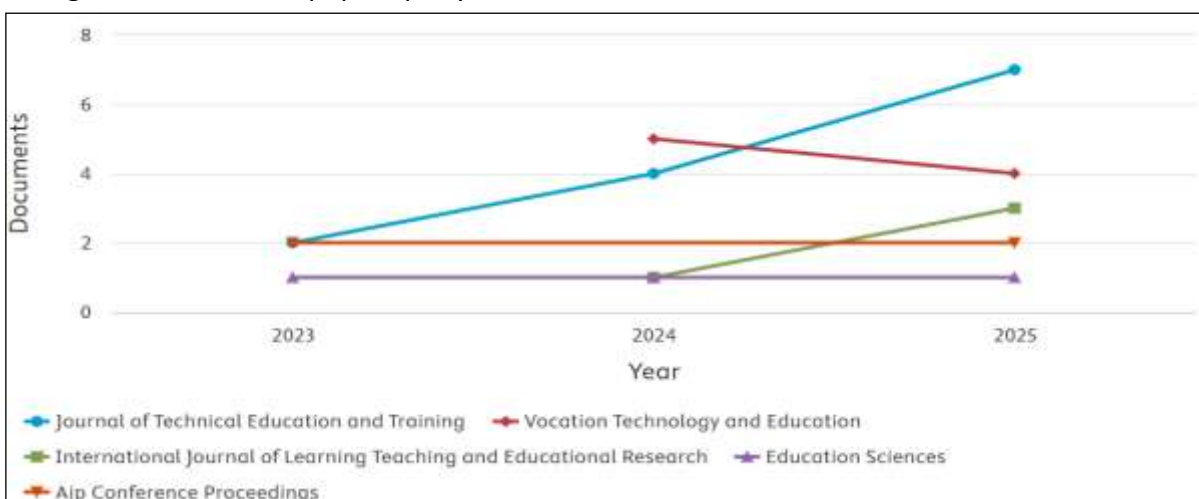


Figure 2. Distribution of publications by top five sources, 2023–2025
(Source: Scopus, processed by the author)

The combination of these two images actually tells two different things, and both are equally important to read together. The first image shows that interest in this topic is growing rapidly in aggregate, while the second image shows that that growth has not yet come down to a single established scientific forum. No single journal is as dominant as a mature field of study, where usually one or two journals are the main references that house the majority of publications as predicted by Bradford's law of classical literature dissemination, which illustrates that in established fields of study, literature tends to be concentrated in a small group of core journals before spreading less and less to peripheral journals (Bradford, 1985). What can be seen in the data of this research is precisely the opposite pattern in the form of a distribution that is still looking for form, where some journals try to be consistent, one journal has excelled and then recedes, and the rest contribute moderately. This kind of condition is commonly found in emerging *research areas*, because the application of Bradford's law basically assumes the existence of a set of specialized journals that are well established in the field, a prerequisite that tends to be difficult to meet on topics that are still very new or cross-disciplinary in nature, when

specialist journals in the field are not sufficiently available so that authors still tend to publish their work in more general forums. The surge in the number of publications at this stage is usually driven by various groups of researchers who move independently, interested in the same issue but not yet aware of each other's existence, if the field continues to develop, condensing towards the scientific community, and a more consolidated publication platform (Sauanova et al., 2026).

This reading is important to place in the broader context of the research itself. The high volume of publications is often misinterpreted as an indicator that a topic has been "extensively researched" so that there is no longer room for new research. However, as will be seen in the next sub-chapter, the increasing number of publications actually goes hand in hand with a pattern of scientific collaboration that is still loose and the distribution of themes that are far from even, so that the number of articles published does not necessarily mean that the question of the need for digital literacy training for vocational teachers has been adequately answered. On the contrary, the rapid flow of publications at this early stage is often a sign that a field of study is moving towards a crucial point, a place of more directed and in-depth research. Instead of scattered and exploratory research, it is needed to give this field a stronger footing.

Productivity and Scientific Collaboration

If the previous sub-chapters indicate that this topic is being written about, the next reasonable question to ask is: crowded by whom, and does that crowd grow from an interconnected scientific community, or rather from many small groups working alone without each other's existence? The answer, as far as can be read from the co-authorship map, leans toward the second possibility. Of the 217 authors identified as being involved in this topic, only 62 authors (about 28.6%) met the minimum engagement threshold to be included in the mapping. This figure itself is not surprising when read through the lens of the law of author productivity formulated by Lotka, who found that in almost all scientific fields, the majority of authors contribute only one publication, while the number of truly productive and sustainable authors is much smaller (Lotka, 1926). What makes this finding worth looking at is not the proportion alone, but the form of the network: the groups of writers who manage to cross the threshold appear as separate small islands, without a single significant connecting line between groups. No author or group stands out as leading scholars, a condition that usually only begins to shift when a field of study enters a consolidation phase, where prolific writers begin to find each other and form the core of a tighter network of collaboration.



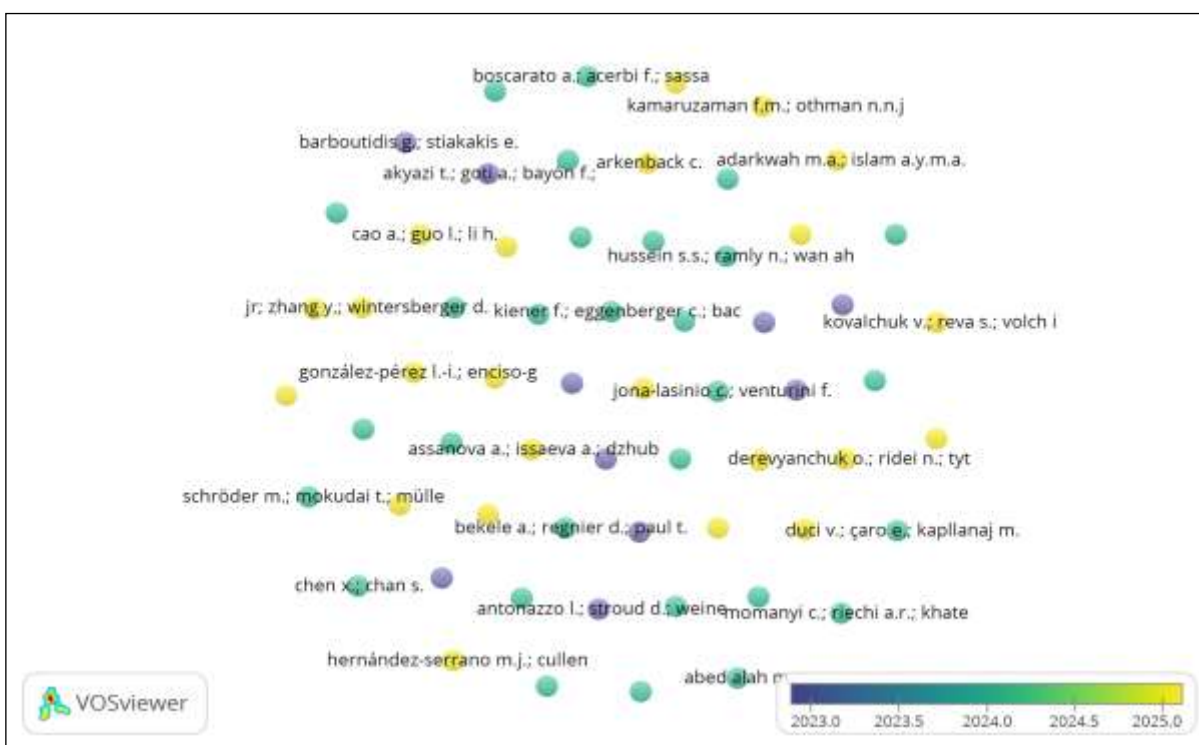


Figure 3. Map of co-authorship networks by author
(Source: VOSviewer)

A similar pattern, even with a sharper degree of fragmentation, is seen at the institutional level. Of the 484 institutions recorded as contributing to this topic, only 10 meet the criteria of at least two publications, a shrinkage that is much steeper than the shrinkage at the writer's level. The remaining ten institutions do not show any interconnectedness to each other on the map, even though they come geographically from quite diverse countries, ranging from several universities in Ukraine, one polytechnic in China, one university in Spain, to international institutions such as the UNESCO-UNEVOC Centre which mandates to focus on education and vocational training at the global level. The presence of UNEVOC in this map is actually quite interesting to contemplate: as an umbrella institution that is supposed to be the link for cross-country TVET research and policy, its position of standing alone without being connected to this map is a small mirror of a larger problem. The institutional collaboration infrastructure on the topic of digital literacy training for vocational teachers has not really been formed, although institutionally there are actually actors who have the potential to be the liaison.

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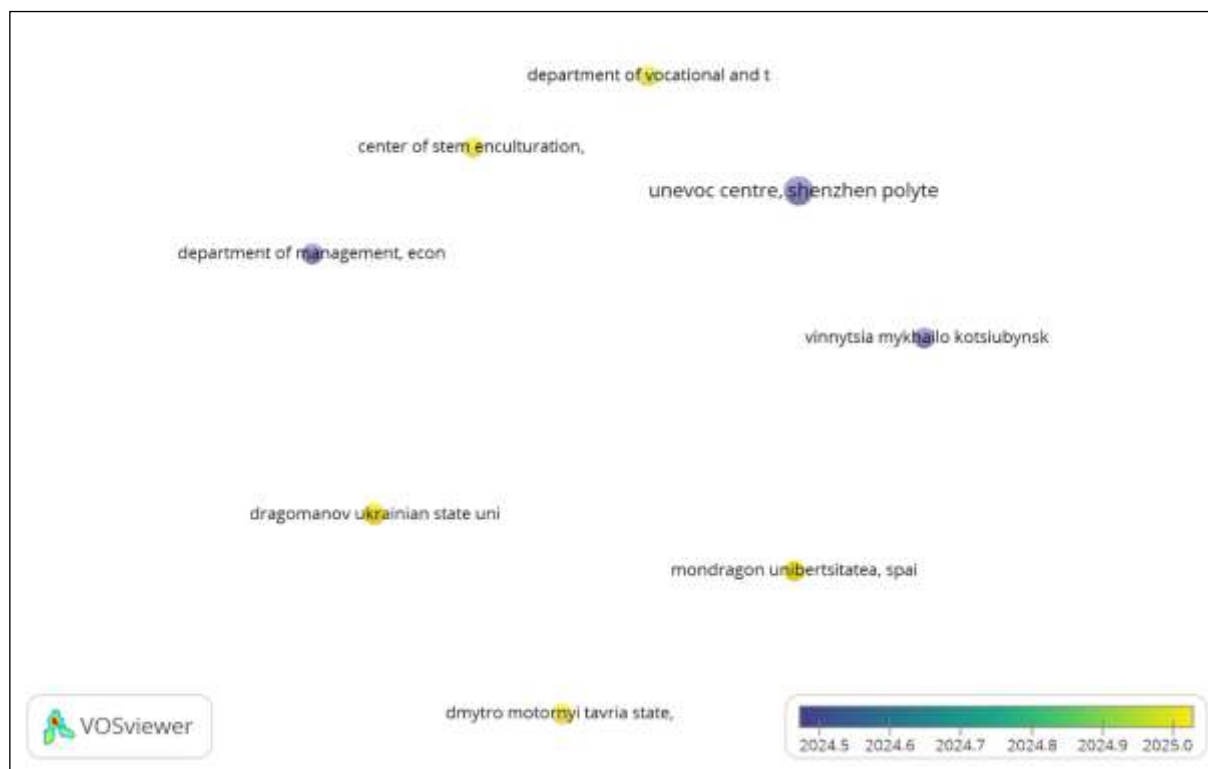


Figure 4. Map of co-authorship networks by institution/organization
(Source: VOSviewer)

A slightly different picture emerges when the unit of analysis is raised to the country level. Of the 64 countries that were recorded as contributing, 11 countries met the threshold of at least five publications, and seven of them actually showed connectivity in the cross-country collaboration network. This is a qualitative leap compared to the previous two levels of analysis, which did not show any meaningful links at all. However, collaboration at the country level did not converge, but was split into two independent sub-clusters: one cluster consisting of Brazil, Spain, and Germany with an earlier publication trail, and the other cluster consisting of China, Malaysia, and Indonesia with a more recent publication trail. China emerged as the largest and most productive node between the two. The absence of a bridge between the two clusters is consistent with findings repeatedly reported in the international scientific collaboration literature, which suggest that geographical distance and language differences remain a real barrier to the formation of cross-regional collaboration, even in the era of digital connectivity

(Glänzel, 1995; Hwang, 2012). This pattern of grouping collaborations based on geographical and historical proximity has long been observed as a characteristic of international research networks, where countries tend to collaborate first with partners who are regionally or culturally closer, before such collaboration extends across continents (Glänzel, 1995).

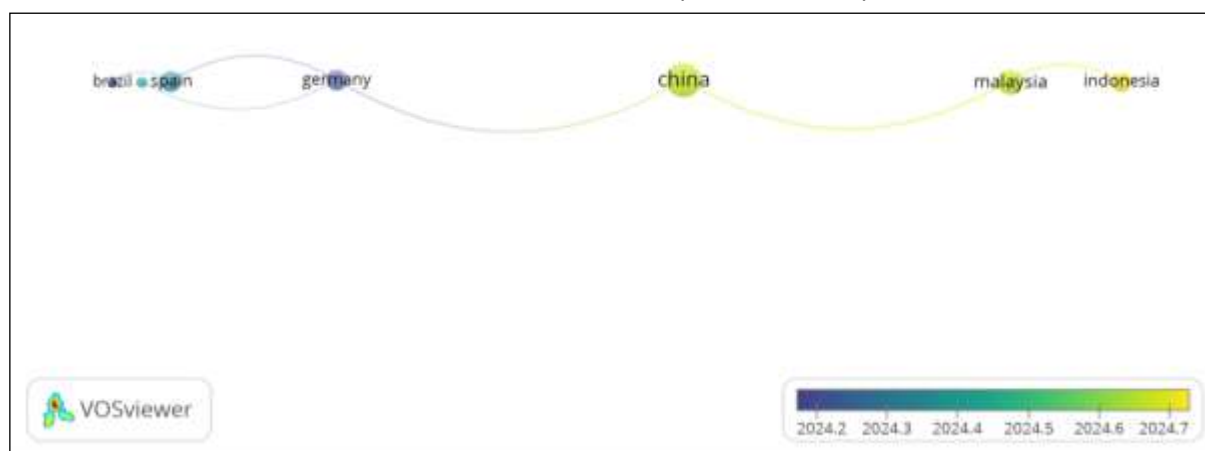


Figure 5. Map of co-authorship networks by country
(Source: VOSviewer)

These three layers of analysis include authors, institutions, and countries, telling a coherent narrative albeit with varying intensities: research on the topic of digital literacy training for vocational teachers grows not from a single deep-rooted and interconnected scientific community, but from a series of efforts that run independently, both at the level of individual researchers, the institutions in which they belong, and the geographical regions in which they work. This pattern is in line with the surge in the number of publications discussed in the previous sub-chapter: both point to the characteristics of fields of study that are still in their early stages, where interest in a topic grows faster than the formation of the scientific social structure that underpins it. The implication is quite important to underline, namely that the lack of cross-group collaboration means that the knowledge generated in this field is still running in parallel and has the potential to overlap, instead of building on each other, a condition that opens up space, as well as confirming the need, for further research that is able to bridge the findings that have been running separately.

Dominant Themes and Trends of Recent Research

While the previous sub-chapters talk about who writes, this sub-chapter talks about what they actually wrote. A co-occurrence analysis of 216 publications yielded 1,514 unique keywords, a figure that in itself illustrates how diverse the perspectives researchers bring to this topic. After filtering with a threshold of at least five occurrences, there are 54 keywords that are representative enough to be mapped into a clearer thematic structure. The resulting map shows five large clusters, and the way these five clusters are formed follows a logic that has long been used in co-word analysis: the more often two keywords appear side by side in the same article, the more closely the two terms are considered conceptually related, so that the groupings that emerge are not just visual coincidences, but representations of the intellectual structure of a field of study (Delecroix & Eppstein, 2004).

What is interesting to observe is not just how many clusters are formed, but how the size of each cluster speaks to the weight of attention that each theme receives. The first cluster, which appears to be the largest and most densely connected, centers on terms such as *apprentices*, *e-learning*, *teaching*, *students*, and *curricula*, a combination that clearly leads to a digital-based vocational learning and teaching process, seen from the perspective of learners and classroom activities. The second cluster, which contains the terms that are most relevant to the specific focus of this research, namely *teacher training*, *teachers'*, and *digital competence*, appears with the smallest size and number of connections among all existing clusters. This irony is worth underlining: the topic that is explicitly the reason for this research is actually the topic that is the least "noisy" discussed in the corpus of literature that has been collected. The other three clusters lead to the theme of digital transformation at the system level, the methodological characteristics of the study, and technology and sustainability issues such as Industry 4.0. These themes are important, but they are one step away from the core of the teacher training problem itself.



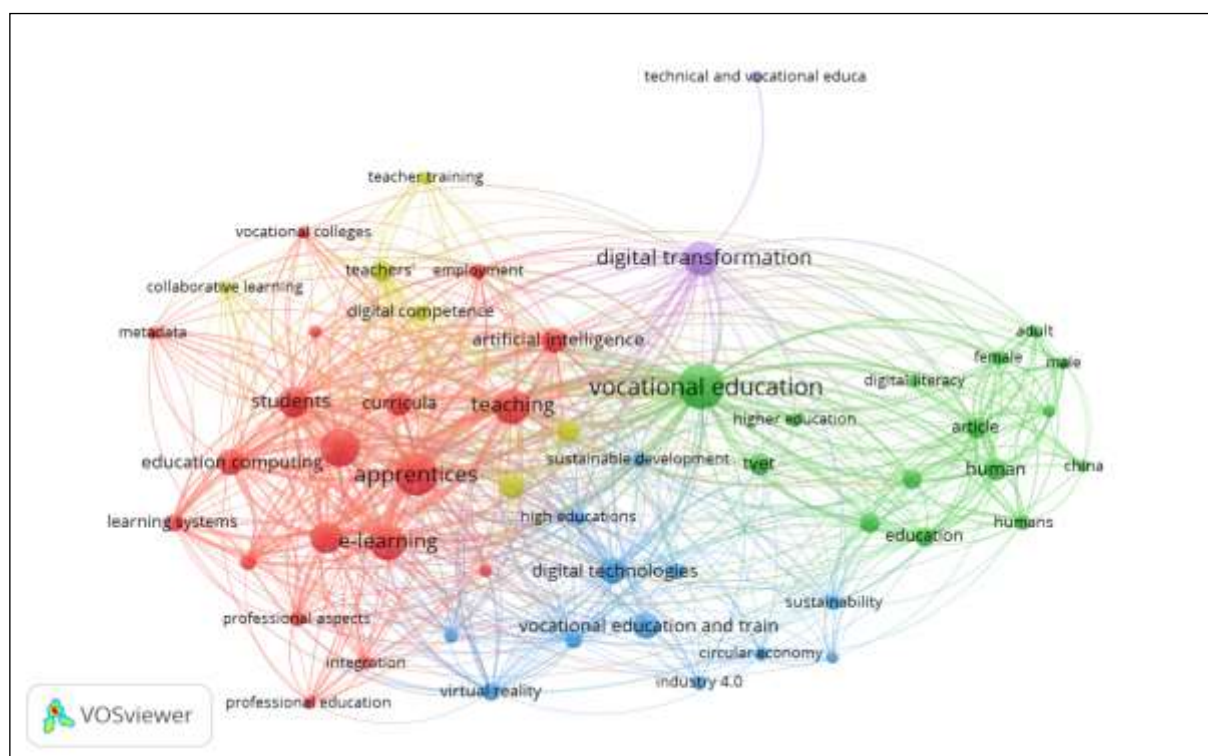


Figure 6. Visualization of keyword co-occurrence networks by thematic cluster
(Source: VOSviewer)

The time dimension displayed through the visualization overlay reinforces, not softens, this impression. Themes such as *teaching*, *e-learning*, and *apprentices* tend to be green to yellow, indicating that these themes are increasingly being discussed closer to 2024 and 2025. These themes move forward, not backwards. On the other hand, terms that explicitly touch the dimensions of teachers and digital competencies, such as *teacher training* and *digital competence*, are in the range of colors that indicate research activities that are not as intense as the students' learning themes. In other words, the mainstream of research on the topic of digital literacy in vocational education is not only greater on the theme of student learning than teacher training, but the flow is also growing faster, so that the gap between the two has the potential to widen instead of narrowing if there is no research intervention that deliberately directs attention to vocational teacher training.

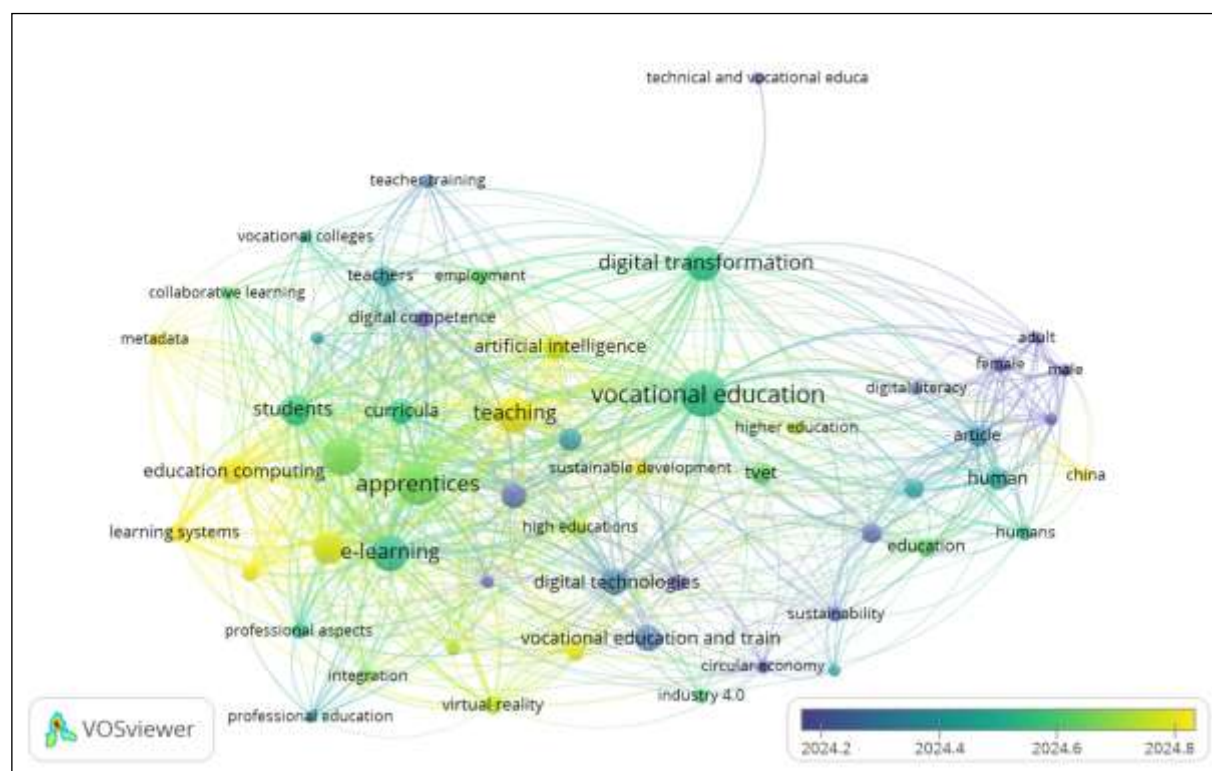


Figure 7. Visualization of keyword overlays by average year of publication
(Source: VOSviewer)

These findings also need to be read side by side with the fact that the academic world actually already has a fairly mature conceptual framework to define teachers' digital competence, one of which is the *European Framework for the Digital Competence of Educators* (DigCompEdu) which outlines the digital competence of teachers into six areas of professional and pedagogical competence (Redecker C., 2017). This is also reflected in the analysis of co-citation in this study, where the work appears as one of the references that are consistently cited together by the collected literature. The availability of such an established conceptual framework should be an adequate capital for the development of empirical studies on vocational teacher training more intensively. However, in reality, as shown by the small cluster of *teacher training* and *digital competence* on this thematic map, the conceptual capital has not been translated into empirical studies that specifically target the context of vocational education. The gap between the availability of theoretical frameworks and the lack of applied studies is ultimately an important

starting point for the urgency of research on the need for digital literacy training for vocational teachers.

Identification of Research Gaps

The three previous sub-chapters have each touched on a piece of the same image, but density visualization is where the image finally appears intact. Unlike network visualization that highlights inter-thematic relationships, and overlay visualization that highlights the time dimension, density visualization is specifically designed to show how "saturated" an area of a topic has been worked on, with light colors indicating a high concentration of study and dark colors indicating areas that are still loose or even empty (Donthu et al., 2021; Fathurochman, 2025; Liu & Xu, 2025). The points with the lightest color intensity on this map are centered on the terms *apprentices*, *e-learning*, *vocational education*, *digital transformation*, and *teaching*. The same five terms that have repeatedly appeared as the largest nodes since sub-chapter 3.3. Conversely, terms that are directly relevant to the focus of teacher training, namely *teacher training*, *digital competence*, *digital literacy*, and *teachers' performance*, appear with much dimmer color intensity, as if immersed in the brighter areas around them.

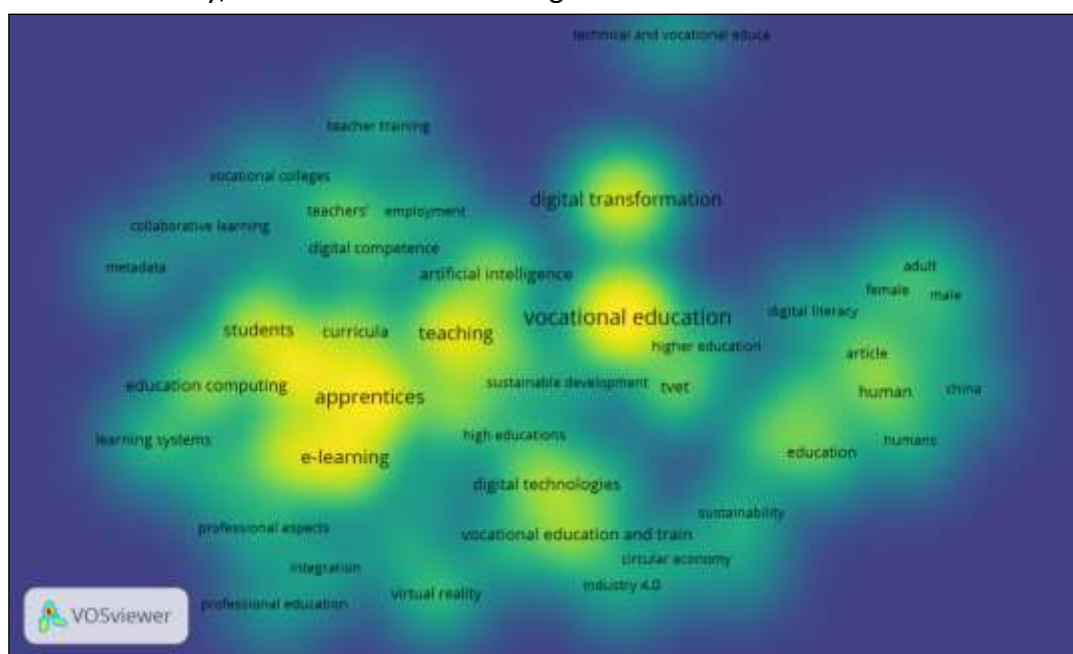


Figure 8. Visualization of keyword density
(Source: VOSviewer)

These findings deserve to be read as strong empirical evidence: even though the literature search process in this study has been specifically limited to the intersection between digital literacy, training, and vocational teachers, the body of knowledge that has been successfully collected is still dominated by the study of vocational learners, not the training and development of digital competencies for teachers themselves. In other words, when the research world talks about "digitizing vocational education", what is more often meant is how students learn with digital tools, not how their teachers are prepared to teach them. This condition is even more meaningful when placed side by side with the findings of the co-citation analysis, which shows that *the DigCompEdu framework* (Redecker C., 2017), still emerges as one of the references that are consistently cited simultaneously by the literature in this field. The gap identified here is not a gap at the level of concepts or theoretical frameworks, the framework is already available and quite established, but there is a gap at the level of empirical application of the framework, especially in the context of vocational education and training.

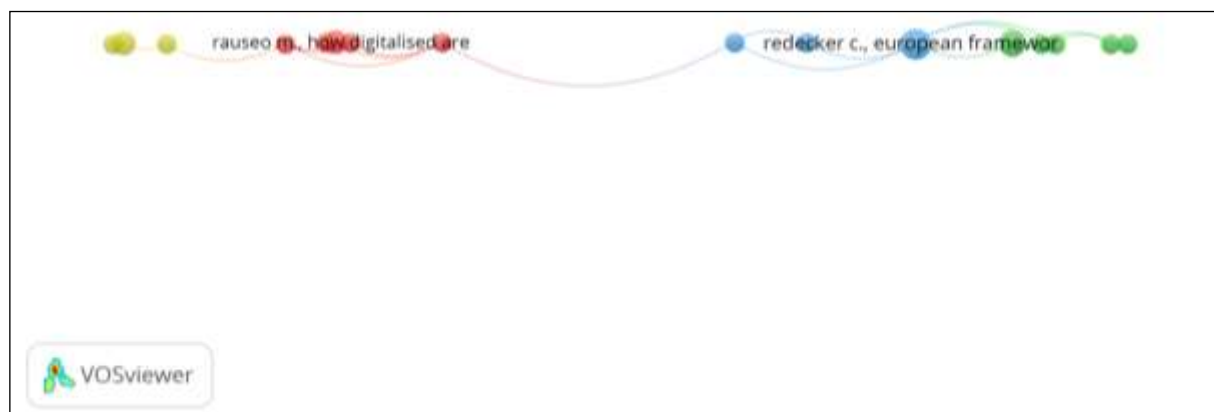


Figure 9. The co-citation map of the references, cited together, shows the emergence of the DigCompEdu framework (Redecker, 2017) as one of the main references
(Source: VOSviewer)

This kind of gap is basically good news as well as news that requires caution. The good news is that there is a clear and unfilled space for research that specifically raises the need for digital literacy training for vocational teachers, this is a gap that is the fundamental reason for this research to be conducted. However, caution is also needed, because the void in the bibliometric map cannot be directly translated into the training needs that are actually felt by vocational teachers in the field; it only shows that the question has not been asked systematically

in the scientific literature, not showing what the answer looks like. To bridge the conceptual gap towards empirical and contextual answers, a methodologically designed approach is needed to measure the gap between the competencies that are ideally possessed and those that are actually mastered by teachers, as is commonly done in the study of training needs analysis based on the discrepancy model, which compares the level of importance of a competency with the level of actual mastery to determine training priorities (Borich, 1980). This kind of methodological footing is the natural bridge between the gaps identified in this bibliometric study and advanced empirical research on the analysis of digital literacy training needs for vocational teachers.

Thus, it can be concluded that there is a real research gap in the empirical study of the need for digital literacy training for vocational teachers. The lack of research density on this theme, combined with the pattern of scientific collaboration that is still fragmented both at the author, institutional, and geographical level levels as discussed in sub-chapter 3.2, as well as the growth of student learning themes that go far beyond the theme of teacher training as discussed in sub-chapter 3.3, together affirm the urgency of conducting further research that specifically analyzes the need for digital literacy training for vocational teachers in realizing 21st century learning as the main focus of this research.

As a concluding note, some of the limitations of this bibliometric study need to be openly acknowledged. First, the data used are single-source from Scopus, so they do not include exclusively indexed literature in other databases such as the Web of Science or regional databases that may contain studies from specific regions in more depth. Second, the time span used (2023–2025) is relatively short for the measure of long-term trend studies, so the patterns identified are more accurately read as portraits of cutting-edge trends rather than historical trends that have been tested over a longer period of time. Third, search restrictions on keywords in document titles have the potential to miss relevant articles that discuss this topic in depth in the abstract or content section without explicitly listing them in the title. These limitations do not reduce the validity of the findings of the research gaps that have been identified, but they need to be considered in interpreting the scope and generalization of the results of this study.

CONCLUSION

This bibliometric research maps 216 documents published throughout 2023–2025 at the intersection between digital literacy, training, and vocational education, in order to answer the four research questions that have been formulated. In terms of publication trends, this study



finds that academic attention to this topic has grown sharply from year to year, from 22 papers in 2023 to 125 documents in 2025, but this growth has not been followed by the formation of a truly established scientific publication platform, with contributions that are still scattered across various journals and proceedings. In terms of productivity and collaboration, this study finds a pattern that is consistently fragmented at the author, institutional, and state levels, with collaboration networks that appear more as small independent groups rather than a single interconnected scientific community, even though at the state level there is a cross-border collaboration that is still polarized into two separate geographical poles.

In terms of thematic structure, this study found that themes directly related to teacher training and digital competence, such as *teacher training* and *digital competence*, appeared as clusters with much smaller size and growth than themes related to vocational learners' learning. This pattern was again confirmed through density visualization, which showed that the theme of teacher training is still loose and has not been widely worked on, even though conceptual frameworks such as DigCompEdu have been established as a theoretical reference. These findings together confirm the existence of a real *research gap* in the study of the need for digital literacy training for vocational teachers empirically. This is a gap that does not lie in the absence of a theoretical framework, but in the lack of application of the framework, especially in the context of vocational education and training.

Overall, the results of this mapping provide an initial answer to the formulation of the research problem on how the need for digital literacy training for vocational teachers can be analyzed in order to realize 21st century learning: not by assuming that a general digital competency framework is sufficient, but by realizing that the vocational context demands a separate empirical study that specifically addresses the real needs of vocational teachers in the field. This bibliometric research is thus positioned as a preliminary study that lays an argumentative and conceptual basis for further research that will measure these needs directly, for example through a *discrepancy analysis* approach that empirically compares the level of importance and mastery of the digital competencies of vocational teachers.

For further research, it is recommended that bibliometric studies on this topic be expanded to involve more than one database (e.g. combining Scopus with the Web of Science) as well as a longer time span, in order to obtain a more stable and representative picture of trends. In addition, given that this study finds that the theme of vocational teacher training is still a minor stream in the overall digital literacy research landscape of vocational education,



advanced empirical research that specifically measures the need for such training, whether through large-scale surveys, in-depth interviews, or a combination of both, is a very relevant direction to follow up to fill the gaps that have been identified in this study

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