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# Microlearning and Nanolearning in Higher Education: A Bibliometric Review to Identify Thematic Prevalence in the COVID-19 Pandemic and Post-Pandemic Context

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**Abstract.** The COVID-19 pandemic led to a significant shift towards more innovative teaching methods, highlighting the need for continuous and flexible learning approaches. Thus, it is relevant to explore the casuistry of the various applications of microlearning and nanolearning in higher education, and identify the thematic trends and topics little explored in the pandemic and post-pandemic scenario. In this sense, the purpose of this study is to carry out a bibliometric review under a quantitative approach and at an exploratory-descriptive level, on the existing literature in the Scopus database. As a result, it was possible to identify that the COVID-19 pandemic has influenced scientific production in the application of microlearning in higher education to a greater extent with respect to nanolearning. Furthermore, the prevalent themes identified in the existing literature are the effectiveness and adaptation of microlearning in different areas of higher education, such as medicine and engineering, the development of competencies and skills through microlearning in university students and the evaluation of

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the impact of innovative teaching strategies such as microlearning in higher education. Therefore, it is concluded that, in the current post-pandemic context, a clear focus on the application, integration and evaluation of the impact of microlearning in higher education prevails; however, a significant gap is identified in the adoption of nanolearning, which is in an emerging phase of development.

**Keywords:** microlearning; nanolearning; higher education; bibliometric review

## 1. Introduction

The COVID-19 health crisis forced a rapid adoption of virtual teaching in many educational institutions (Mendoza, 2020). Despite the growing interest in educational technologies such as e-Learning, M-Learning and B-Learning, universities had not, however, foreseen a complete transition towards a virtual pedagogical model (Mejía-Flores et al., 2020). Although some universities had a long tradition of distance learning, the vast majority of institutions were characterised by a marked tradition of face-to-face teaching (Álvarez-Herrero, 2020). Under this scenario, various challenges were evident in guaranteeing an optimal online teaching-learning process (Avendaño et al., 2021). As such, the greatest challenge was to link teaching practice with emerging technological tools, which, in some cases, were very alien to teachers and students; nevertheless, little by little, they became allies to enable the educational process to continue (Cipagauta, 2021). Consequently, technology and educational needs led to generating new forms of student-teacher interaction, with smartphones, tablets and laptops being the technological devices that contributed the most (Cerezo et al., 2023).

Already placing ourselves in the post-pandemic context, the growth of mobile technologies expanding the range of possibilities for learning is evident, also the understanding that smartphones and tablets are the two mobile devices with the greatest use of the Internet (Mondragón, 2022; Valencia-Arias et al., 2023). Given the above, mobile learning (M-learning) takes on great relevance since it allows students to review educational content unlimitedly and understand it in a better way, since it is organised and structured (Torres, 2023). This creates a scenario to build new educational resources more adapted to the needs of students and technological development (Herrera & Moreno, 2023). Consequently, the relevance of didactic mediation with these tools focuses in many cases on the combination of M-Learning with microlearning or nanolearning, strategies that enhance innovation and transformation of teaching, highlighted for their agility and focus on the brief and specific (Cervantes & Álvarez, 2021).

Microlearning and nanolearning address the need for methods that do not cognitively overload the student (Ugalde & González-Cabrera, 2022; Velastegui, 2023), offering concise but complete audiovisual materials, for clear and specific learning objectives (Gómez & Simón-Medina, 2022; Nivelá-Cornejo et al., 2021). Microlearning generates educational experiences with a modular structure and short duration, such as webinars, workshops and seminars, focused on the

development of specific skills (Moreno, 2023). On the other hand, nanolearning has the same objective as microlearning in that it seeks for students to learn certain content in small units (Lucero & Maldonado, 2022; Padilla, 2019). However, here the videos are shorter, with many of them created on social networks such as TikTok (Careaga, 2022).

The importance of these learning methodologies is that the student works with techniques that are conducive and suitable for each of them, and which can be used within class and their own homes, achieving learning through autonomy and independence (Sanchez, 2023). That is, the student does not necessarily have to be in the classroom, whether in synchronous or asynchronous classes, in face-to-face processes or digitally, which is different from the concept of virtuality (Pineda, 2022). This also facilitates training and improves knowledge retention, since it is based on the assumption that short and dynamic content captures and retains users' attention much better than traditional content, such as written texts (Moreno, 2023). It also supports teachers in improving teaching practice in terms of both methods and content (Hernández & Talavera, 2021). Among the important factors in the design of these teaching strategies is the production of digital content, particularly video (Leal, 2021). With duration being a very significant indicator, it has been shown that a greater learning commitment is achieved in students in videos of six to nine minutes in length (Yausen, 2022), while nanolearning is based on the use of brief content with a duration of less than five minutes (Núñez, 2023). That is to say, the secret lies in the use of short portions of content (Filippi et al., 2023), the management of which is limited by the capacity of the device used and the availability of the user's time, hence the importance of synthesis to have an impact on the design and presentation of information (Matute, 2022).

However, teaching strategies based on information and communication technologies (ICT) are effective only if they are used as support in various subjects, benefiting both teaching and learning (Lora, 2022). In addition to design options, the effectiveness of microlearning depends on several aspects related to the student, such as their roles, time availability, habits and motivation, while the available technological infrastructure and the learning environment are also crucial for its success (Salas-Díaz & González-Bello, 2023). In short, it is important to highlight that students not only need to know how to understand and use the various technological options they encounter, but they must also learn to use them with all possible ethical sense (Martínez, 2022).

From the above, the objective of this study is to explore and describe the prevalence of thematic contents referring to scientific production developed through microlearning and nanolearning in higher education, in the COVID-19 pandemic and post-pandemic context. The study is developed under the bibliometric review method, on studies published in the Scopus database from 2020 to the present. Through this study, we seek to contribute to the identification of predominant trends in the field of study in question, as well as the identification of gaps and research opportunities in particularly less attended sub-areas; representing this information is useful to guide future research that

contributes to the current state of the art on microlearning and nanolearning. Based on the above, the research questions (RQ) for this study are:

- RQ1: How has the COVID-19 pandemic influenced scientific production in the application of microlearning and nanolearning in higher education?
- RQ2: Which bibliographic sources and which researchers contribute to the greatest extent in the publication of studies regarding the application of microlearning and nanolearning in higher education in the COVID-19 pandemic and post-pandemic context?
- RQ3: What topics are the most prevalent in the existing literature on microlearning and nanolearning in higher education in the COVID-19 pandemic and post-pandemic context?

## **2. Methodology**

### **2.1 Research approach**

This study adopted a quantitative approach, based on the use of bibliometric indicators, to describe and analyse scientific production related to microlearning and nanolearning in higher education, in the COVID-19 pandemic and post-pandemic context. In this way, an objective and systematic evaluation of the bibliographic data will be carried out, appropriate to answer the research questions posed. This approach is supported in some cases by the analysis of secondary data, which were statistically examined, to identify results (Acosta, 2023; Huamán et al., 2021).

### **2.2 Scope of the investigation**

This study has an exploratory-descriptive scope, as it seeks to discover and map trends and patterns regarding scientific production on microlearning and nanolearning in higher education, and in the COVID-19 pandemic and post-pandemic context. It provides a detailed and current description of bibliometric data that allows establishing thematic prevalence in the existing literature. In this regard, Ramos (2020) points out that research has an exploratory scope because it allows an initial exploration of a specific area of study; it is the starting point for carrying out any research. Likewise, Arias and Covinos (2021) point out that studies with descriptive scope mainly focus on detailing the properties of a particular phenomenon or group that is being investigated, providing insight into its characteristics within a particular context.

### **2.3 Data collection process**

To collect the data, that is, the scientific publications that were part of the bibliometric review study, it was first considered to define the search equation based on the keywords linked to microlearning and nanolearning in higher education, and in the COVID-19 pandemic and post-pandemic context. From this consideration, the following search equation was obtained for the compilation of publications from the Scopus database: (TITLE-ABS-KEY ("microlearning" OR "micro-learning" OR "nanolearning" OR "nano-learning") AND TITLE-ABS-KEY ("education" OR "teaching") AND TITLE-ABS-KEY ("university" OR "Higher Education")). The Scopus database was used because it stores a range of scientific studies from various disciplines, which includes scientific publications on microlearning and nanolearning in higher education

and which have been rigorously evaluated under various criteria such as blind peer review. This helps the study ensure that the information extracted is reliable and relevant to the study. In this regard, Codina et al. (2020) state that the Scopus database is used by the international scientific community because it has vast coverage in all areas of knowledge. Furthermore, Auza-Santivi  nez et al. (2020) highlight that Scopus is established as the most extensive database of global scientific literature, mainly made up of academic publications and conference proceedings, these journals having been rigorously evaluated with academic standards, particularly the peer review process.

Another important aspect to highlight in the data collection process was the method used, which is an adaptation of the PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analysis) methodology and validated by the scientific publication developed by Chamorro-Atalaya et al. (2023). This method consists of three stages that lead to the selection of publications for the analysis of bibliometric indicators. Initially, the topic to be investigated was defined, this being microlearning and nanolearning in higher education. In this first stage, 135 publications were identified, as a result of applying the search equation in the Scopus database, that is, without considering the publication period of the studies during and after the COVID-19 pandemic. The second stage consisted of a screening of the manuscripts identified in the first stage, in which specific criteria were applied such as the scope of the cases addressed in the studies must be in higher education, and not in initial, primary or secondary education. Another aspect was that the publications be open access in all their content; in addition, it was also limited to publications during the years 2020 to 2024. In this second stage, 94 publications were identified. Finally, in the third stage, a review of the summaries and complete content of each publication selected in the previous phase was carried out. In this way, we sought to determine that the publications included in this final stage were suitable and consistent with the topic under study, minimising the possible biases present in the research. At this stage, 90 scientific publications were identified. Figure 1 shows in detail the process of collecting scientific publications at each stage.

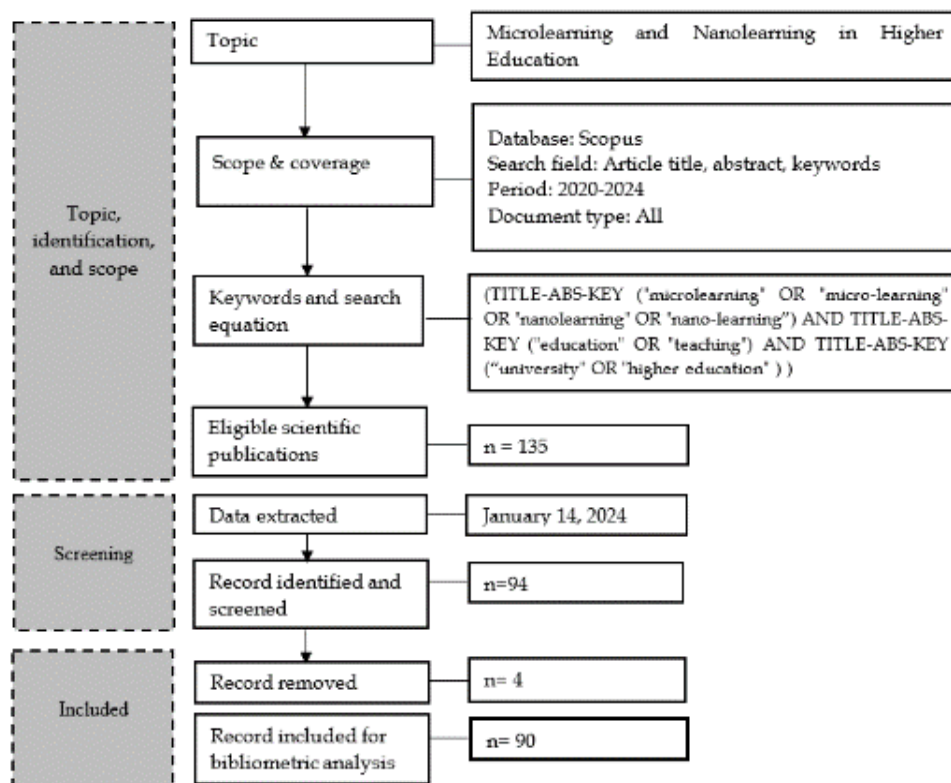


Figure 1. Data collection process

## 2.4 Data processing and analysis

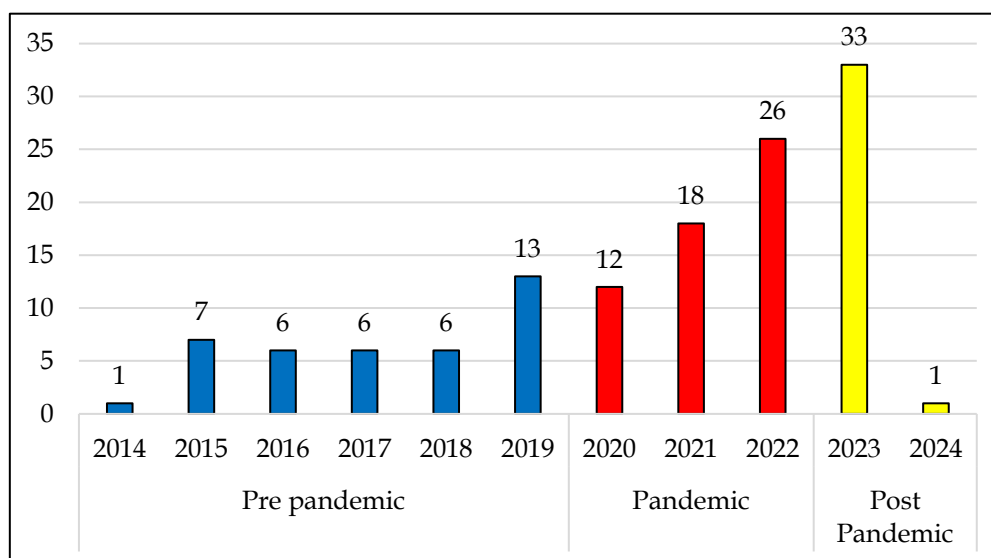
For the processing and analysis of the collected data, two specialised and widely used software for bibliometric analysis were used, VOSviewer and Bibliometrix. These software contributed to the generation of reports on scientific production by year of publication, bibliographic sources and authors with the highest number of citations, representations of co-occurrence and grouping networks, by which it was possible to identify the prevalent themes and gaps in the field of study on microlearning and nanolearning in higher education. In this regard, George and Avallo-Martínez (2021) point out that the VOSviewer software is a widely used tool to perform bibliometric analysis. Furthermore, Pedraja-Rejas and Rodríguez-Ponce (2021) state that Bibliometrix is a tool designed for quantitative research in scientometrics and bibliometrics, which facilitates the description and monitoring of publications to identify trends in various areas of study.

## 3. Results and discussion

### 3.1 How has the COVID-19 pandemic influenced scientific production in the application of microlearning and nanolearning in higher education?

Although the study focused on analysing bibliometric indicators regarding scientific production in the application of microlearning and nanolearning in higher education in the pandemic and post-pandemic context, to answer this first question it was also necessary to include information regarding the studies published in the pre-pandemic scenario, with the purpose of identifying the impact and at the same time establishing the influence of the pandemic on scientific production in this field of study. In this sense, it was possible to

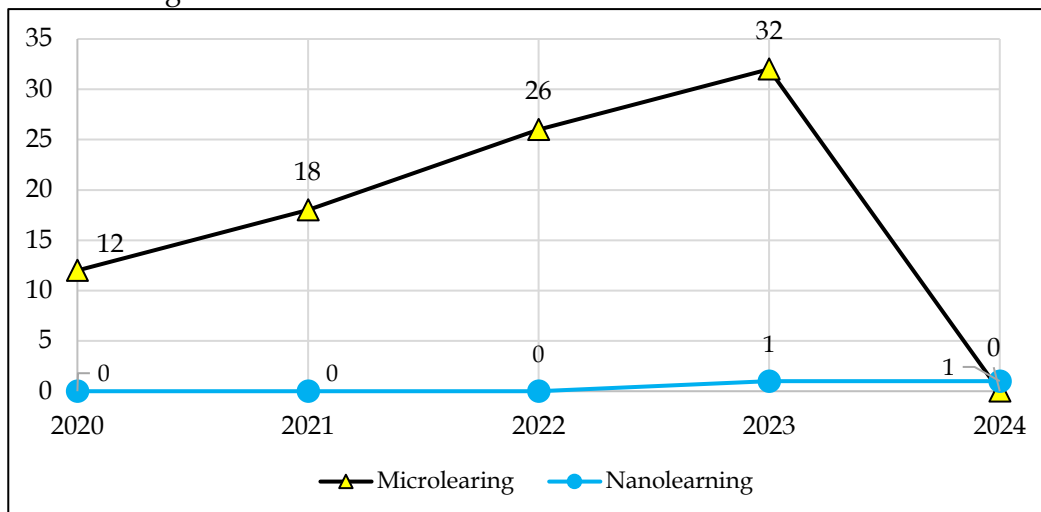
identify that, before the pandemic and taking 2014 as the initial year of the analysis, an increasing trend was observed in the number of publications, going from one publication in 2014 to thirteen in 2019, thus evidencing that the annual increase is relatively moderate, with an average annual number of publications of 6.5. However, during the pandemic period, a significant increase in the number of publications is observed from 12 publications in 2020 to 26 publications in 2022, thus reaching an annual average of 18.67. This shows greater interest in research into learning methodologies as a response by higher education institutions to the need to adapt to the challenges that have arisen as a result of the COVID-19 pandemic, such as migrating towards online teaching modalities online and remote. In the post-pandemic period, the upward trend continues with a production of 33 publications in 2023 and so far in 2024 there is already one publication, reaching an annual average of 17. Figure 2 shows the annual scientific production in the pre-pandemic, pandemic and post-pandemic scenarios of COVID-19. Focusing strictly on the pandemic and post-pandemic period, a growing and sustained interest is evident, to a greater extent in the application of microlearning than with respect to nanolearning, given its effectiveness as a methodology in higher education. In addition to this impact and positive influence of the COVID-19 pandemic on scientific production, it can also be added that this increasing number of publications has been influenced by the widespread use of mobile devices, greater access to the Internet and the advancement of ICT.



**Figure 2. Scientific production, in the pre-pandemic, pandemic and post-pandemic scenarios of COVID-19**

These factors have contributed to developing and adopting new teaching strategies that align with the requirements of education 4.0, characterised by being more digital, interactive and adapted to students. However, it is perceived that scientific production focuses more on the field of microlearning than nanolearning. Of the 90 publications included in this review study, 88 publications correspond to microlearning and only two correspond to nanolearning, both of which were in the last two years. This is possibly because

that, while microlearning has been a more immediate option and has already shown evidence of its effectiveness in learning to address educational challenges during the pandemic, nanolearning is only now beginning to gain attention as a valuable focus on the continued evolution of higher education in a post-pandemic context, seen as a complement to microlearning. Figure 3 shows the annual scientific production by field of study between microlearning and nanolearning.



**Figure 3. Annual scientific production, by field of study between microlearning and nanolearning**

In this regard, Betancur-Chicué and Muñoz-Repiso (2023), in their review study on the use of microlearning in the educational field, show that, after a search process in the Scopus and Web of Science databases, they identified a total of 34 publications, determining greater scientific production during the years 2020 to 2022 (pandemic context), compared to the years 2018 and 2019 (pre-pandemic context). They also identified that microlearning is closely linked to concepts such as virtual education and the recent COVID-19 pandemic. Durán and Escudero (2023) used the Science Direct, ERIC, Scielo and Redalyc databases to extract their publications for the development of their review study, and selected 14 studies of which seven were identified between 2018 and 2019, while, during the years 2020 to 2021, they also identified the same number of publications. They also established that trends and advances in educational technology experienced an exponential acceleration due to the situation created by COVID-19 in classrooms worldwide. This scenario is what drove the adoption and interest in microlearning as an innovative and effective approach in education. Likewise, Al-Nasheri and Alhalafawy (2023), in their research on microlearning in education in the context of the COVID-19 pandemic, point out that microlearning proved to be particularly effective during this scenario as a strategy to provide continuity to the teaching-learning process. This effectiveness underlines the importance of its study in understanding educational strategies during the post-COVID-19 phase, so as to adapt and improve educational processes in a global context. Finally, with respect to the application of nanolearning, Chanyawudhiwan and Mingsiritham (2023) point out that the COVID-19 pandemic has highlighted the importance of distance



education adapting to unforeseen learning circumstances, which is why nanolearning turns out to be a methodology that takes advantage of contemporary information technologies to address the personalised and individual learning that the student requires.

### 3.2 What bibliographic sources and what researchers contribute to the greatest extent in the publication of studies regarding the application of microlearning and nanolearning in higher education, in the COVID-19 pandemic and post-pandemic context?

In relation to the bibliographic sources that have contributed to the greatest extent to the publication of studies on the application of microlearning and nanolearning in higher education, in the COVID-19 pandemic and post-pandemic context, a total of 43 sources were identified bibliographically, of which 36 are scientific journals and seven are conference proceedings. Furthermore, when analysing the number of publications (NP) in this period of time, it was identified that, of the total bibliographic sources, 42 only have one publication on the topic under study, while only one bibliographic source, specifically a scientific journal, has published five studies. This journal with the highest number of contributions is **Education and Information Technologies** having a total number of citations (TC) equal to 67, evidencing its high impact and contribution to the existing literature. Furthermore, when analysing the h-index of this scientific journal according to Scientific Journal Rankings (SJR), it was identified that it has a value of 61, which places it in the Q1 quartile. Table 1 shows the ten best bibliographic sources with the greatest contribution in the field of study. This classification is not only focused on the total number of publications but also on the total number of citations generated by said publication, specifying the year in which the document was cited for the first time (PY\_start). As can be seen, there are various scientific journals with a high number of citations and in the Q1 quartile, which demonstrates the high impact and interest of the academic scientific community in studies on the application of microlearning and nanolearning in higher education, in the context of COVID-19.

**Table 1. The 10 best bibliographic sources with the greatest contribution in the field of study**

Source	NP	TC	PY_start	h_index	Quartile according to SJR
Education and Information Technologies	5	67	2021	61	Q1
Multimedia Tools and Applications	1	45	2021	93	Q1
Journal of Work-Applied Management	1	40	2021	It was not found	No assigned quartile
Applied Sciences (Switzerland)	1	20	2020	101	Q2
Journal of Computing in Higher Education	1	19	2020	47	Q1
Sustainability (Switzerland)	1	17	2021	136	Q1

Communications in Computer and Information Science	1	15	2022	62	Q4
Proceedings of 2020 IEEE International Conference on Teaching, Assessment, and Learning for Engineering, TALE 2020	1	13	2020	It was not found	No assigned quartile
Education in the Knowledge Society	1	11	2020	18	No assigned quartile
Asian Association of Open Universities Journal	1	10	2021	13	Q2

Furthermore, when analysing the most relevant author who contributes the most to the field of study based on the impact of his scientific work, it was identified to be Aguilera-Hermida et al. (2021) and their study entitled "Comparison of students' use and acceptance of emergency online learning due to COVID-19 in the USA, Mexico, Peru, and Turkey". Likewise, the second author whose study has the greatest impact is that of Redondo et al. (2021), whose publication is titled "Integrating micro-learning content in traditional e-learning platforms". Another aspect that was identified in these studies is the metric called "Normalized Global Citations" (NGC), which represents the total number of citations that a scientific publication has with respect to the average citations of all publications published in the field of study. This metric is used to compare the impact of different publications across disciplinary barriers. In this way, the study developed by Aguilera-Hermida et al. (2021) presents an NGC of 5.29, that is, this study has been cited 5.29 times more than the average number of citations in its field, thus reflecting a highly relevant and significant impact in the study area. Table 2 shows the 10 authors whose publication have the highest number of citations, with respect to the field under study.

**Table 2. The 10 authors whose publications have the highest number of citations, with respect to the field of study**

Author	Published document	TC	NGC
Aguilera-Hermida et al. (2021)	Comparison of students' use and acceptance of emergency online learning due to COVID-19 in the USA, Mexico, Peru, and Turkey	57	5.29
Redondo et al. (2021)	Integrating micro-learning content in traditional e-learning platforms	45	4.18
Leong et al. (2021)	A review of the trend of microlearning	40	3.71
Skalka and Drlik (2020)	Automated Assessment and Microlearning Units as Predictors of At-Risk Students and Students' Outcomes in the Introductory Programming Courses	20	2.93
Cheng et al. (2020)	Using digital badges as goal-setting facilitators: a multiple case study	19	2.78

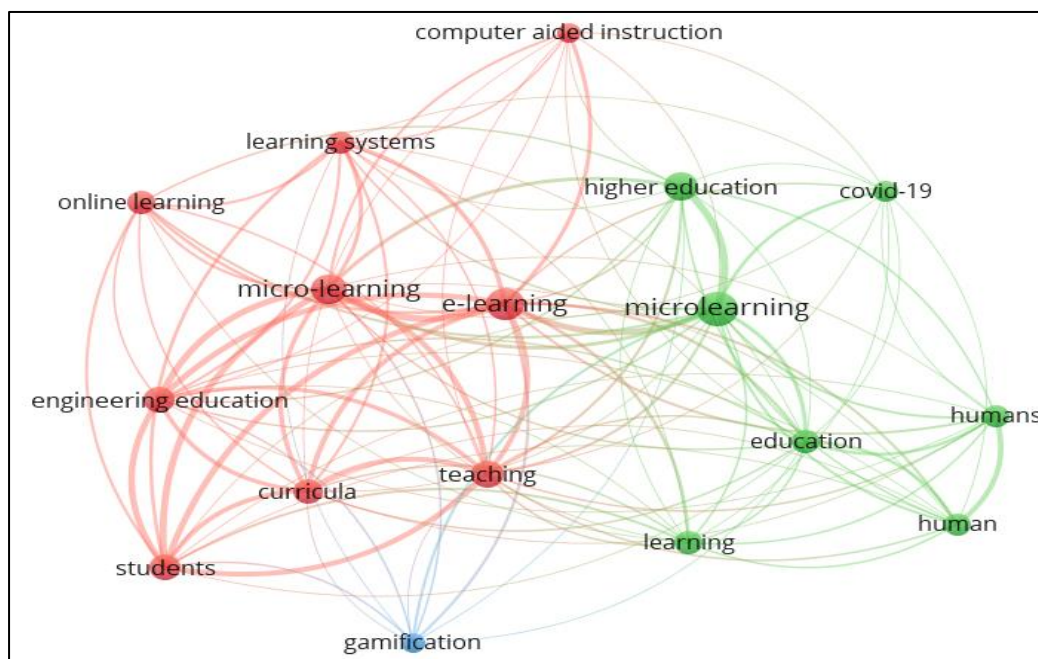
Skalka et al. (2021)	Conceptual Framework for Programming Skills Development Based on Microlearning and Automated Source Code Evaluation in Virtual Learning Environment	17	1.58
Alam and Mohanty (2022)	Metaverse and Posthuman Animated Avatars for Teaching-Learning Process: Interperception in Virtual Universe for Educational Transformation	15	7.80
Gill et al. (2020)	The Future of Teaching Post-COVID-19: Microlearning in Product Design Education	13	1.90
Miguel and Laserma (2020)	Learning Pills for the Improvement of University Education: the Case of the Degree Thesis in the Degree of Linguistics and Applied Languages of University of Cadiz	11	1.61
Kossen and Chia-Yi (2021)	Trialling micro-learning design to increase engagement in online courses	10	0.93

From the results obtained, it is evident that there is no scientific journal that particularly presents a high number of studies on the application of microlearning or nanolearning in higher education, in the COVID-19 pandemic and post-pandemic context. Only the scientific journal *Education and Information Technologies* presents five publications in the field of study, while the others have only published one study. This result shows that there is a need to undertake further studies concerning the topic in question, highlighting that the studies reviewed show a high level of impact. In this regard, Gallent (2022) points out that microlearning is acquiring greater importance in the university environment, and, although this methodology is not entirely new, its application in supporting students is still in its early stages, he specifies that he has not identified experiences in other universities comparable to his study.

Likewise, along those same lines, Gill et al. (2020) point out that microlearning represents an innovation that is booming and that contributed to addressing the challenges in the teaching and learning process during the development of online class sessions during the COVID-19 pandemic. Consistent with the need to address more studies on microlearning and nanolearning, Chen et al. (2022) point out that these educational strategies, although not very novel, were emphasised due to the considerations caused by the COVID-19 pandemic. Likewise Wang et al. (2020) state that, following the outbreak of COVID-19, there has been greater exploration into the widespread adoption of microlearning in various educational institutions. Abrego et al. (2021) point out that, currently, studies on microlearning in higher education are relevant since they will allow evaluating its impact in the university educational field, recognising that educational innovation is crucial in modern times.

### 3.3 What topics are the most prevalent in the existing literature on microlearning and nanolearning in higher education, since the beginning of the COVID-19 pandemic?

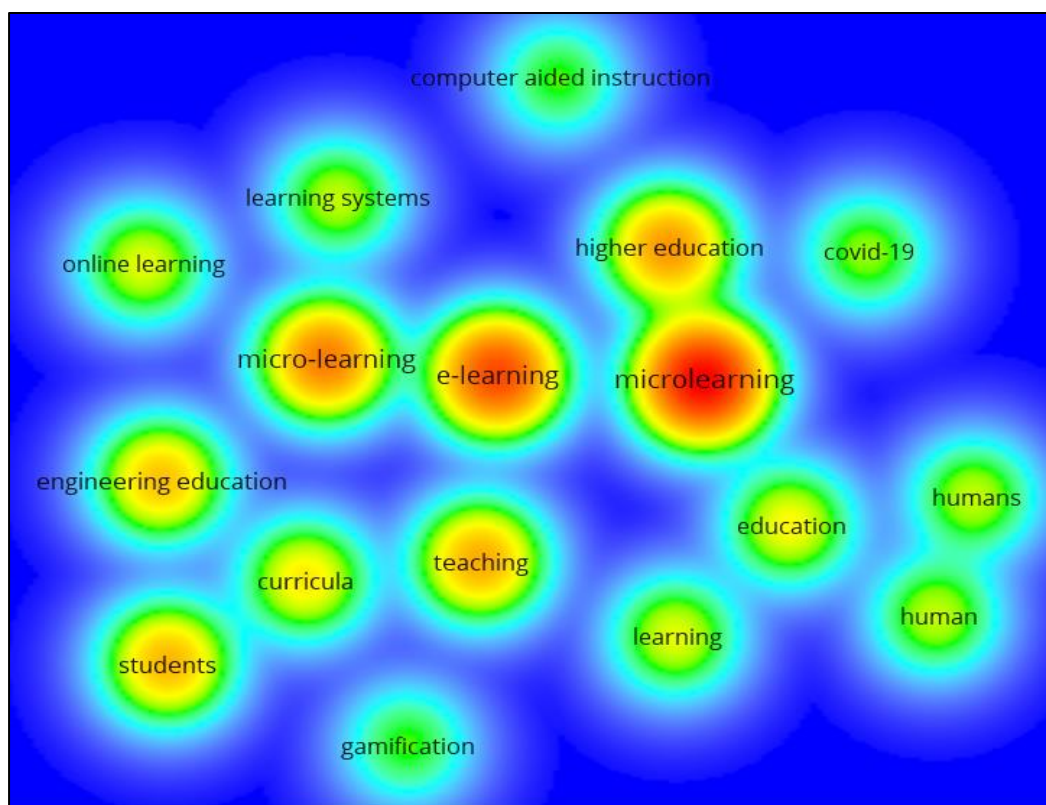
Prior to identifying the prevalent themes in the existing literature on microlearning and nanolearning in higher education, the co-occurrence network of keywords was generated through the VOSviewer software, with the purpose of identifying the terms related to the field of study. In this way, it was possible to identify, based on the nodes (terms or keywords) and their corresponding sizes, that terms such as “e-learning”, “micro-learning”, “microlearning”, “higher education”, “students”, “teaching”, “engineering education” and “curriculum” present a level of occurrence greater than or equal to 10. Thus, the three terms with the highest number of occurrences are “microlearning” with 38 occurrences, “e-learning” with 27 occurrences, and “micro-learning” with 20 occurrences. Figure 4 shows the co-occurrence network of terms or keywords on microlearning and nanolearning in higher education, taking into account publications from the Scopus database, during the pandemic and post-pandemic period. It can be seen that the link strengths with greater intensity represent how related the terms or key words are to each other. In this sense, the term “e-learning” can be identified, showing a link strength of 89, “micro-learning” a link strength of 74, “microlearning” a link strength of 59, as well as “students”, while teaching presents a link strength of 58 and “engineering education” presents a link strength of 57; these being the keywords with the greatest link strength.



**Figure 4. Network of co-occurrences of terms or keywords about microlearning and nanolearning in higher education**

Another aspect analysed was the density network generated from the VOSviewer software, in which the brightest and warmest points in the network indicate the areas of greatest thematic concentration. In this way, it is possible to

identify that the points corresponding to the terms “e-learning”, “micro-learning”, “higher education” and “COVID-19” are focal points, which suggests that these topics are highly prevalent in the literature related to the field of study. Furthermore, if we focus on the proximity and intensity of the terms “micro-learning” and “e-learning”, it is observed that these are close and have a high colour density, so it can be stated that these topics are closely related linked in the scientific publications analysed. Likewise, the visibility of the term COVID-19 in relation to “higher education” and “microlearning” represents that the pandemic has had a substantial impact on how these topics have been addressed in that particular context. On the other hand, the analysis leads us to establish that terms related to “computer aided instruction”, “learning systems”, “engineering education”, “curriculum”, “teaching”, “learning”, “students”, “education”, “humans”, and “human” have been discussed in conjunction with microlearning, which implies a wide range of applications in educational settings in which this methodology has been applied since the COVID-19 pandemic and post-pandemic. Finally, it can be considered that an emerging area that is currently being less addressed is the application of gamification as an innovative element as part of microlearning and nanolearning strategies in higher education, which implies that particular attention should be paid to this for future studies research. Figure 5 shows the network of keyword densities about microlearning and nanolearning in higher education.



**Figure 5. Network of keyword densities on microlearning and nanolearning in higher education**

Based on the results, the prevalent themes are “effectiveness and adaptation of microlearning in different areas of higher education, such as medicine and

engineering”, “development of competencies and skills through microlearning in university students”, and “evaluation of the impact of innovative teaching strategies such as microlearning in higher education”. In this regard, Betancur-Chicué and Muñoz-Repiso (2023) point out that the prevalent fields of study on microlearning are research in the field of health, education and engineering. Along the same lines, Dahiya and Bernard (2021), in their study on the implementation of microlearning in medical education, point out that the pandemic scenario has clearly shown the urgency of incorporating microlearning into education with short videos, with a running time less than sixty minutes. On the other hand, in relation to the fact that one of the prevalent topics is the Development of competencies and skills, Santos and Bastos (2020), in their study on the use of microlearning in teaching practice, points out that it was identified that 82% of the respondents totally agrees that the microlearning methodology can provide some type of skills outside the discipline developed by the teacher, such as diversification and learning digital tools. While in relation to the fact that one of the prevalent topics is the Evaluation of the impact of innovative teaching strategies such as microlearning in Higher Education, Qian et al. (2021) points out that using microlearning showed an increase in effectiveness in both the acquisition and conservation of knowledge, without requiring additional time or greater effort on the part of the teacher. This resulted in a favorable attitude among medical students. Similarly, Rodríguez and Ramírez (2020) in their study of microlearning in Higher Education obtained that by applying this methodology, the participants in the workshops fully satisfied their expectations; the majority of students expressed a clear interest and curiosity in the use of microlearning.

#### **4. Conclusion**

From the bibliometric review on the topic under study, it was possible to identify that the COVID-19 pandemic has influenced scientific production in the application of microlearning in higher education to a greater extent than with respect to the application or use of nanolearning. This is because, as a result of the pandemic, many universities found themselves having to adapt to online and remote teaching modalities, which was also associated with the widespread use of mobile devices, greater access to the Internet and the advancement of information and communications technologies. Likewise, it was also identified that there is no scientific journal that has published a high number of studies on the application of microlearning or nanolearning in higher education, in the pandemic and post-pandemic context. Only the scientific journal *Education and Information Technologies* presents five publications, while the others have only one publication. This result shows that there is a need to undertake further studies concerning the topic in question. On the other hand, it was identified that the most prevalent themes in the existing literature on microlearning and nanolearning in higher education, in the COVID-19 pandemic and post-pandemic context, are effectiveness and adaptation of microlearning in different areas of higher education, such as medicine and engineering, development of competencies and skills through microlearning in university students, and evaluation of the impact of innovative teaching strategies such as microlearning in higher education. Finally, it is concluded that, in the post-pandemic context, a

clear focus on the application, integration and evaluation of the impact of microlearning in higher education prevails; however, a significant gap is identified in the adoption of nanolearning, which is in an emerging phase of development. Future studies could also address how gamification contributes to increasing participation and retention in microlearning.

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