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Abstract

Gaining a clear understanding of publication trends and research themes helps researchers determine gaps in the existing literature and explore new areas of study. The objective of this current inquiry is to describe the research themes related to nanolearning and microlearning in general. The bibliometric method was employed using the Lens Scholarly Search Database from year 2020 to 2024. Additionally, “nanolearning” and “microlearning” were used as queries on the title, keyword, and abstract. Using the analysis from the database and VOSviewer, the publication-related metrics of the scholarly works were determined including the research themes, frequent keywords, and authors' collaboration. Results revealed that there is a growing trend in the use of nanolearning and microlearning in different subjects and contexts. Visualization analysis identified three (3) emergent research themes, namely: (1) the use of nanolearning and microlearning during the pandemic and post-pandemic period, (2) evaluation of the effectiveness of the approaches, and (3) applications and development of tools and strategies. Conversely, nanolearning remains an emerging area with a lower publication count in the analysis. Moreover, Indonesia and the United States are the leading countries in publications. Further, the study revealed active collaboration among authors. Lastly, it is recommended to explore nanolearning as a complementary approach to microlearning.

Introduction

As education evolves to meet the changing demands of society, technology, and learners' needs, diverse approaches to learning are being applied across various disciplines and contexts. Two of these are the use of nanolearning and microlearning to deliver short, focused content to the audience. These approaches are known to address the challenges related to students' cognitive load. Moreover, Sweller et al. (2011) highlight that our working memory would only be able to absorb small amounts of information at any given time. This emphasizes the importance of preventing the overloading of our working memory to maximize learning. Additionally, research suggests that teaching instructions would be more effective when they are tailored to the limitations of working memory. Notably, nanolearning and microlearning, which involve delivering highly focused, bite-sized learning units, are strongly supported by Cognitive Load Theory (CLT). Further, according to Nanjappa et al. (2022), microlearning typically lasts 2-5 minutes, offering formal and informal learning nuggets focused on a single objective, while nanolearning consists of informal learning nuggets of less than 2 minutes, providing a

compressed form of microlearning that focuses on key learning points within the objective.

Moreover, Khlaif and Salha (2021), Garcia et al. (2022), and Yousef et al. (2023) described that nanolearning and microlearning may be presented in engaging formats, such as posts on Twitter, TikTok, podcasts, mobile applications, or even text messages. Moreover, in these approaches, teachers break down topics into smaller, manageable parts—like slicing a pie into four sections. Hence, learners can then choose which specific part they want to focus on, allowing for more personalized and targeted learning. On the other hand, Bal et al. (2023) expanded on the theory of microlearning. According to Bal and colleagues (2023), microlearning is based on two key assumptions about learning. First, it addresses how both content and procedural knowledge are acquired in microlearning and how design choices impact that acquisition. Additionally, microlearning is characterized by chunking and simplifying content into focused segments, guided by specific design considerations to support effective learning. Notably, two crucial microlearning aspects are emphasized by the authors: the integration of cognitive elements and multimedia principles to enhance knowledge acquisition and the use of reflective practices to support the application of knowledge.

Meanwhile, the study Yousef et al. (2023) provide a comprehensive overview of nanolearning (NL), focusing on the design and implementation of nanolearning materials in various educational contexts. Additionally, they propose measures to ensure the quality of nanolearning designs and present best practices for creating effective NL designs/ materials. Notably, the authors introduce the NANO framework for implementing nanolearning in diverse educational settings, emphasizing four key elements: Need, Affordable design, Necessary strategies, and Operation, which are essential for effective NL design. Furthermore, many studies have highlighted the importance of the use of nanolearning and microlearning such as increased self-confidence, positive shifts in mindsets regarding financial matters and life choices (Prandini & Ficarelli, 2021), enhanced students' vocabulary (Azwati et al., 2024), and improved learning experiences (Ali et al., 2023).

On the other hand, Leong et al. (2020) describe the trends of microlearning by employing a comprehensive literature review. Additionally, the authors utilize and analyze data from Scopus and Google Trends, which include 14 years of real-world information from different publications related to microlearning. Results show that from 2006 to 2019, microlearning publications increased 47 times, demonstrating its growing relevance compared to related fields like e-learning. The authors reveal that microlearning is a global topic often linked to e-learning and mobile learning. Additionally, higher education and language learning are the topics most frequently covered. The study concludes that microlearning is emerging as a significant educational trend, urging educational stakeholders to promote and explore it in the classroom. Lastly, the proponents suggest that cross-disciplinary research is imperative to enhance its application in workplace learning and higher education.

Likewise, Chamorro-Atalaya et al. (2024) conducted a quantitative and bibliometric review, exploring the prevalence of thematic content in scientific publications in the Scopus database on the use of microlearning and nanolearning in higher education during and after the COVID-19 pandemic. The authors identify key trends, research gaps, and opportunities for future studies. Notably, the findings reveal that the pandemic significantly increases the volume of research on microlearning in higher education, reflecting a growing interest in flexible

learning methods. Lastly, the authors recommend that future studies focus on both microlearning and nanolearning in education to address gaps in the use of the approach.

Although research suggests that both microlearning and nanolearning can significantly benefit learners, several researchers emphasize that neither approach should be viewed as a replacement for traditional education. Moreover, the approaches are most effective when used as supplementary tools to enhance engagement, knowledge retention, and skill development (Kayalar, 2021). Additionally, the literature also highlights the importance of teacher support during the implementation of such approaches to optimize the learning experience for students (Ali et al., 2023). This suggests that, despite the focus on technology and concise content delivery, the role of the teacher remains crucial in guiding and facilitating effective learning in both microlearning and nanolearning environments. On the other hand, most previous reviews on approaches have focused solely on the Scopus or Web of Science databases. For many scholars, the primary drawback of Web of Science and Scopus is their limited accessibility (Wilder & Walters, 2021), and some studies in the field may not be indexed in these databases. Therefore, the present study explores an alternative open-access database to provide research scholars with the emerging themes in nanolearning and microlearning including the gaps in the literature.

Building on the premise above, the current study focuses on the thematic content of research publications related to nanolearning and microlearning in general. This study employs a bibliometric review methodology using the Lens Scholarly Search Database, covering the years 2020 to 2024. By systematically analyzing the trends, patterns, and prevalence of key topics within this timeframe, the study aims to provide insights into the current state of knowledge, identify existing research gaps, and demonstrate emerging opportunities for future exploration. The findings will serve as a valuable resource for scholars, educators, and other educational stakeholders by providing a comprehensive overview of the field and guiding the development of impactful and innovative studies in nanolearning and microlearning. This contribution is particularly timely given the growing emphasis on flexible, technology-driven learning approaches in the post-pandemic educational landscape. Generally, this study aims to determine the research activities on nanolearning and microlearning. Specifically, the investigation focuses on answering the following research objectives:

1. Determine the publication-related metrics of journal articles included in the bibliometric analysis in terms of:
    a. publications per year and citing scholarly works
    b. most cited articles
    c. top journals
    d. top publishers
    e. top field of study
    f. top institutions
    g. most active authors
    h. most active countries
2. Describe the emergent research themes on nanolearning and microlearning using network visualization of the title and abstract data.
3. Describe the keyword co-occurrences and co-authorship in the research publications.

Method

This current study is a bibliometric analysis of various research focused on nanolearning and microlearning. According to Hallinger and Kovačević (2023), a bibliometric review is a specialized type of systematic literature review (SLR) designed to determine the patterns in publication, production, and accumulation. Unlike traditional reviews, bibliometric reviews do not focus on individual studies or concentrate on synthesizing research findings. Instead, this approach employs quantitative software tools such as VOSviewer, Bibliometrix, Gephi, and CiteSpace to analyze bibliographic data from extensive collections of documents, typically sourced from scholarly search databases like Scopus, Web of Science, Lens, and Dimension. In this particular analysis, the researcher uses one database and a quantitative visualization and exploration tool to provide insights into the studies focused on nanolearning and microlearning. Moreover, the researcher employed the bibliometric analysis procedure outlined by Donthu et al. (2021). To elaborate, the researcher began by defining the aims and scope of the current bibliometric review. Next, the proponent selected the appropriate analysis techniques based on the established aims and scope. This was followed by data collection, which involved selecting the desired database, retrieving data, and cleaning it by removing duplicates and erroneous entries. Finally, the researcher performed the analysis and discussed the findings, focusing on the performance analysis or science mapping.

Database

One of the important parts of the bibliometric analysis is selecting the appropriate database. For this study, the Lens Scholarly Search Database was utilized. The Lens serves as a public resource for global patent and scholarly knowledge, supporting science and technology-driven problem-solving. By bridging the worlds of scholarly research, invention, and industry, the Lens facilitates the discovery, analysis, and mapping of global innovation knowledge. Its core features include aggregating metadata and full text, combining unique content sets such as scholarly works, patents, and biological sequences (Lens.org, n.d.). Notably, the Lens offers advanced management tools such as filtering capabilities for scholarly works, enabling researchers to collect and organize publications tailored to different research contexts.

Search Strategy and Export of Data for Visualization

The search for publications on nanolearning and microlearning followed the comprehensive and systematic scholarly search outlined in Table 1. Additionally, the search process was conducted on January 13, 2025. Initially, a query focused on the titles, keywords, and abstracts of documents related to nanolearning and microlearning yielded 1057 records. Applying inclusion criteria—such as publication years (2020–2024), document type (journal articles), and open-access availability—along with abstract filtering, narrowed the results to 365 journal articles. Finally, a manual review was conducted to exclude articles not focused on nanolearning and microlearning, not written in the English language, duplicated articles, and categorized as review articles. In summary, the scholarly search process resulted in 247 studies.

Table 1. Scholarly Search of Publications on Nanolearning and Microlearning

Scholarly Search Process	**Scholarly Works**
Query: Title: nanolearning OR (Abstract: nanolearning OR (Keyword: nanolearning OR (Title: microlearning OR (Abstract: microlearning OR Keyword: microlearning))))	1057
Filtered by Date Range: 2020-2024	824
Filtered by Document Type: Journal Article	544
Filtered by Flags: Open Access	389
Filtered by Flags: Has Abstract	365
In the English Language and Original Research Paper *(Systematic Literature Review and Duplicates Excluded)*	247

The articles retrieved through the search process were exported in RIS format, a standardized tag format created by Research Information Systems, Inc., to enable data exchange between citation management programs (Texas A&M University Libraries, 2024). The exported data was subsequently used in VOSviewer (Version 1.6.20) to create visualizations for analysis. Likewise, the analysis tool within the database was employed to examine the characteristics of the articles the configurations used are line graphs and heat maps.

Results and Discussion

In this section, a detailed analysis of publication-related metrics of the studies was presented including the emergent themes of nanolearning and microlearning research.

Distributions of Publications per Year and Citing Scholarly Articles

Figure 1 highlights a notable increase in the number of publications focused on nanolearning and microlearning, reflecting a growing interest within the academic community. Furthermore, the data reveals scattered citations across the analyzed studies, indicating a diverse range of applications and research contexts. This trend suggests that, although nanolearning and microlearning are becoming increasingly popular, their theoretical foundations and practical applications still vary greatly and are spread across a wide range of disciplines. In addition, Sankaranarayanan et al. (2022) reported an increasing trend in microlearning, with an estimated annual growth rate of 33.5%.

Likewise, Monib et al. (2024) documented an annual growth of 19.37% in microlearning research from the year 2007 to 2023. Overall, this indicates that publications were focused on the use of microlearning from different contexts including the use of the approach in education. Furthermore, Mochamad (2024) also documented an increase in citations of the study focused on microlearning. Consistent with the current review, the increase in citations of studies in microlearning, as shown in Figure 1, indicates a steady accumulation of studies from July 2021 to October 2024.

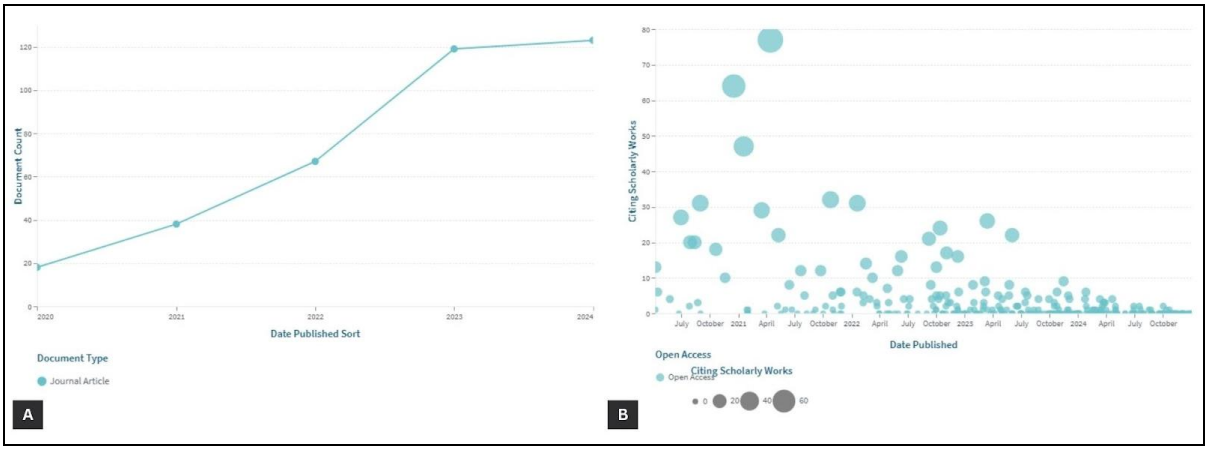

Figure 1. Publications per Year (A) and Scholarly Citations (B) (Source: Lens.org)

Despite the increasing research interest in microlearning, nanolearning studies remain largely underexplored. Noteworthy, this current study found only three (3) publications mentioned nanolearning, while most of the published articles primarily focused on microlearning in various contexts and disciplines. These results corroborate the findings of the review conducted by Chamorro-Atalaya et al. (2024), which included only two (2) articles on nanolearning from 2023 to 2024. Moreover, they suggest that this could be the start of increasing attention to research on the use of nanolearning in academia after the pandemic, particularly to complement the implementation of microlearning in higher education. Similarly, Yousef et al. (2023) emphasized that nanolearning is a new and innovative approach that delivers bite-sized learning content that facilitates effective retention. While research on the method is still limited, this could be the starting point for using nanolearning to enhance education.

Most Cited Articles

Table 2 presents the top articles with the highest citation counts, this demonstrates the most relevant publications based on the impact of scholarly work in the field of nanolearning and microlearning. Notably, the study by Aguilera-Hermida et al. (2021), titled *"Comparison of Students' Use and Acceptance of Emergency Online Learning Due to COVID-19 in the USA, Mexico, Peru, and Turkey,"* recorded the highest citation count of 77. These findings corroborate with those of Chamorro-Atalaya et al. (2024), who also identified this article as the most cited in their review. The second most-cited study, with 50 citations, was published by Dokukina and Gumanova (2020) with the title *"The Rise of Chatbots – New Personal Assistants in Foreign Language Learning."* Additionally, the study by Rickardsson et al. (2021), titled "*Internet-Delivered Acceptance and Commitment Therapy as Microlearning for Chronic Pain: A Randomized Controlled Trial with 1-Year Follow-Up,"* garnered 47 citations.

Table 2. Most Cited Articles on Nanolearning and Microlearning

Authors	Title of the Scholarly Works	Citations
Aguilera-Hermida et al. (2021)	Comparison of students' use and acceptance of emergency online learning due to COVID-19 in the	77

Authors	Title of the Scholarly Works	Citations
	USA, Mexico, Peru, and Turkey.	
Dokukina and Gumanova (2020)	The rise of chatbots – new personal assistants in foreign language learning	50
Rickardsson et al. (2021)	Internet-delivered acceptance and commitment therapy as microlearning for chronic pain: A randomized controlled trial with 1-year follow-up	47
Carter and Youssef-Morgan (2022)	Psychological capital development effectiveness of face-to-face, online, and Micro-learning interventions.	31
Skalka et al. (2021)	Conceptual Framework for Programming Skills Development Based on Microlearning and Automated Source Code Evaluation in Virtual Learning Environment	29
Skalka and Drlik (2020)	Automated Assessment and Microlearning Units as Predictors of At-risk Students and Students' Outcomes in the Introductory Programming Courses	27
Fidan (2023)	The effects of microlearning-supported flipped classroom on pre-service teachers' learning performance, motivation, and engagement	26
Wang et al. (2021)	Towards Post-pandemic Transformative Teaching and Learning: Case Studies of Microlearning Implementations in Two Post-secondary Educational Institutions	22
Conde-Caballero et al. (2023)	Microlearning through TikTok in Higher Education. An evaluation of uses and potentials.	22
Zarshenas et al. (2022)	The effect of micro-learning on learning and self-efficacy of nursing students: an interventional study	21

Top Journals

The journal *Education and Information Technologies* was identified as the leading contributor to publications on nanolearning and microlearning, with four articles published. Chamorro-Atalaya et al. (2024) also highlighted this journal as the top contributor in the field. Additionally, this current review documented that the journal has a total of 156 citations, demonstrating its significant impact and contribution to the existing body of literature on publications related to nanolearning and microlearning. Furthermore, an analysis of the journal's h-index, as reported by Scientific Journal Rankings (SJR), revealed a value of 76, placing it among Q1 (Quartile 1) journals. The next leading journal is *BMC Medical Education*, which has garnered 27 citations from three (3) published articles. Furthermore, according to SJR, the journal has an h-index of 97 and is classified as a Q1 (Quartile 1) journal. Figure 2 shows other journals with the number of citations related to nanolearning and microlearning.

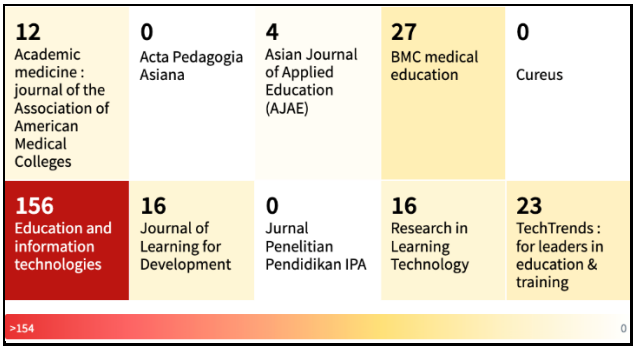

Figure 2. Top Journal with the Most Number of Publications and Citations (Source: Lens.org)

Top Publishers

The top publishers were identified by counting the number of publications produced. As shown in Table 3, Springer Science and Business Media LLC emerged as the leading publisher in the field of nanolearning and microlearning, with 23 articles published between 2020 and 2024. This indicates that Springer is the primary contributor to research in this area during the specified period. Notably, Springer is a renowned global leader in scientific, technical, and medical publishing, providing high-quality content to researchers in academia, scientific institutions, and corporate R&D departments. As a German multinational company, Springer specializes in publishing books, e-books, and peer-reviewed journals across science, humanities, technology, and medical disciplines (Springer, 2024). Similarly, Wiley and Elsevier BV contributed 10 and 9 articles, respectively. Moreover, the table highlights other publishers along with their corresponding journal article counts and citations on nanolearning and microlearning.

Table 3. Top Publishers with the Number of Scholarly Works Published and Citations

Publisher	**Scholarly Works***	**Citations***
Springer Science and Business Media LLC	23	289
Wiley	10	66
Elsevier BV	9	70
Oxford University Press (OUP)	6	6
Frontiers Media SA	5	12
MDPI AG	4	65
Universitas Negeri Jakarta	4	0
International Association of Online Engineering (IAOE)	4	15
JMIR Publications Inc.	4	14
Lembaga Intelektual Muda Maluku	4	0

**Source: Lens.org*

Top Field of Study

The field of study was identified by categorizing the articles into various disciplines, with some articles tagged

under multiple fields due to their broad scope and diverse themes. Unlike previous literature reviews, the current investigation reports the primary fields of study focused on the application of nanolearning and microlearning. Notably, according to the analysis from the Lens Scholarly Search Database, psychology emerged as the leading field with 166 studies, followed by computer science with 160 documents and mathematics education with 100 publications. This diverse distribution of fields highlights that nanolearning and microlearning are applied across various disciplines and contexts. Moreover, Corbeil et al. (2023) stressed that microlearning's flexibility and other unique features make it easy to incorporate into both digital and non-digital formats. This adaptability allows it to be effectively used in different academic settings, whether formal or informal. Lastly, Figure 3 shows the other top fields of study with their corresponding article count.

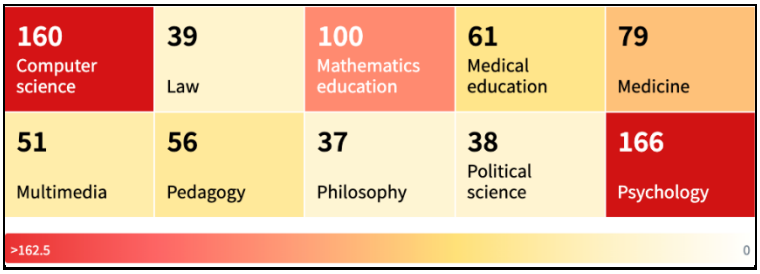

Figure 3. Top Field of Study in Nanolearning and Microlearning (Source: Lens.org)

Top Institutions

Table 4 illustrates that the State University of Jakarta led in the number of publications on nanolearning and microlearning, with a total of 13 articles. This was followed by the University of Sydney and the Indonesia University of Education, each contributing 4 publications. These findings suggest that multiple institutions are actively engaging in research on the applications of nanolearning and microlearning. The State University of Jakarta's prominence highlights its significant focus on advancing this field, while the contributions from other institutions demonstrate growing global interest and collaboration in exploring innovative educational approaches. Moreover, the results indicate that Hacettepe University received the highest number of citations among universities, despite producing only two articles. It was followed by the University of Sydney with 24 citations and the Mayo Clinic with 15 citations. The table also illustrates other institutions and the number of articles they produced including their respective citations.

Table 4. Top Institutions with the Most Scholarly Works Published

Institutions	Country	Scholarly Works*	Citations*
State University of Jakarta	Indonesia	13	1
University of Sydney	Australia	4	24
Indonesia University of Education	Indonesia	4	12
Vanderbilt University	United States	3	14
Utrecht University	Netherlands	3	3
University of Malaya	Malaysia	3	6

Institutions	Country	Scholarly Works*	Citations*
State University of Makassar	Indonesia	3	0
Mayo Clinic	United States	2	15
Institut Teknologi dan Bisnis Kalbe	Indonesia	2	5
Hacettepe University	Turkey	2	77

**Source: Lens.org*

Most Active Authors

The most active scholars were identified by counting the number of publications produced. As shown in the analysis of the Lens Scholarly Search Database, Table 5 presents the authors and their respective publication counts. Siti Drivoka Sulistyaningrum emerges as the most prolific author, with five articles on nanolearning and microlearning, all published in 2023. Following her are authors with four publications each: Fenny Yutika Seli, George Veletsianos, Jaigris Hodson, Ratna Dewanti, and Shandell Houlden.

Table 5. Prolific Authors with the Number of Scholarly Works Published and Citations

Authors	Country	Scholarly Works*	Citations*
Siti Drivoka Sulistyaningrum	Indonesia	5	1
Ratna Dewanti	Indonesia	4	1
Fenny Yutika Seli	Indonesia	4	0
Jaigris Hodson	Canada	4	7
George Veletsianos	Canada	4	7
Shandell Houlden	Canada	4	7
Ifan Iskandar	Indonesia	3	0
Lisette Schoohoven	Netherlands	3	3
Jeroen Dikken	Netherlands	3	3
Christiani Thompson	Canada	3	6

**Source: Lens.org*

Most Active Countries

The research output by country was analyzed from 2020 to 2024, as shown in Figure 4. Indonesia, represented by a darker green shade, emerged as the leading contributor to research publications on nanolearning and microlearning, with a total of 36 publications. The United States followed as the second-highest contributor, producing 19 articles. On the other hand, Leong et al. (2020) and Mochamad (2024) noted in their literature review that the United States has been a leader in microlearning research, contributing the most retrieved studies from the Scopus database. Interestingly, the previous data, along with the current findings, highlight the ongoing and sustained research interest in microlearning. Moreover, the figure also illustrates the contributions of various countries, with darker green indicating higher research output and lighter green to white signifying fewer

publications on nanolearning and microlearning.

Figure 4. Most Active Countries in Publication (Source: Lens.org)

Emergent Research Themes on Nanolearning and Microlearning

Using VOSviewer, the research themes were identified by mapping frequently occurring terms in the title and abstract fields of documents related to nanolearning and microlearning. With a minimum occurrence threshold of 20, the analysis yielded 28 items, distributed into three clusters representing the three distinct and emerging themes (see Figure 5).

1. The first cluster, highlighted in red, consists of 13 items arranged alphabetically: ability, covid, evaluation, knowledge, learner, learning, microlearning, opportunity, pandemic, paper, part, system, and training. Notably, the dominant item in this cluster, as well as in the overall analysis, is "microlearning," which has 27 links, a total link strength of 1050, and 174 occurrences.
2. The second cluster, highlighted in green, consists of 8 items arranged alphabetically: data, effectiveness, group, impact, participant, research, study, and survey. Noteworthy, the dominant term in this cluster is "study," which has 27 links, a total link strength of 908, and 152 occurrences.
3. The third cluster, highlighted in blue, consists of 7 items arranged alphabetically: application, development, student, teacher, time, topic, and video. Additionally, the prominent term in this cluster is "student," which has 27 links, a total link strength of 728, and 114 occurrences.

It can be noted that the first cluster highlights *the use of microlearning in educational and training contexts, particularly during the COVID-19 pandemic including the post-pandemic period.* Additionally, due to the situation during that time, the learners must enhance their ability to acquire knowledge effectively and adapt to

remote learning environments. Moreover, terms like opportunity and system suggest a focus on using microlearning as a strategy for addressing challenges brought about by the pandemic.

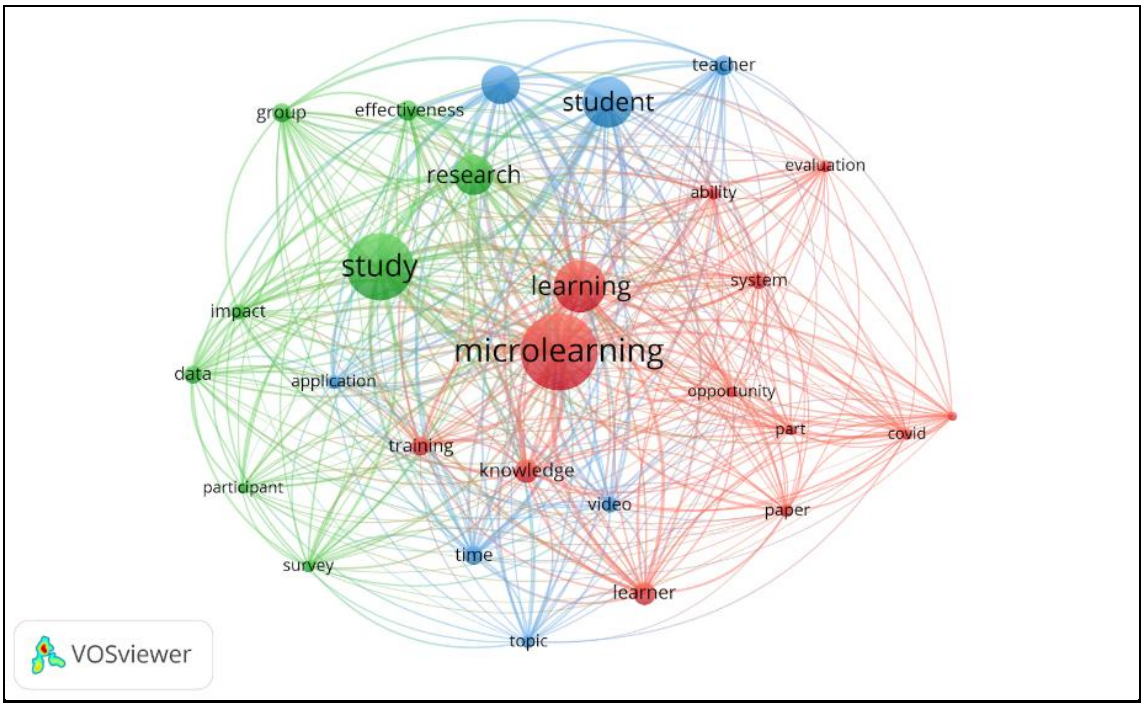

Figure 5. Network Visualization Analysis of Title and Abstract

In the second cluster, it can be noted that scholarly works were focused on *the evaluation of the effectiveness of microlearning and nanolearning*. Additionally, using the key terminologies in the cluster, the growing research was highlighted by analyzing their impact on different groups of participants through data-driven studies and surveys. Lastly, the emphasis on effectiveness and impact suggests ongoing research endeavors to validate these approaches in diverse educational and professional settings.

In the third cluster, it can be inferred that the publications were more focused on the *practical applications of nanolearning and microlearning.* The inclusion of terms like teacher, time, and video indicates a focus on designing and implementing these approaches to enhance the learning experience for students. The term development highlights the ongoing efforts to refine learning tools or resources to support the integration of these methods into different educational contexts.

Overall, the emerging themes were corroborated by the findings from the literature review of Aburizaizah and Albaiz (2021) and Sankaranarayanan et al. (2022) who reported that the trends in the publications on microlearning were due to the opportunities and challenges brought by the COVID-19 pandemic. Likewise, authors documented similar themes such as the evaluation of the effectiveness of the approaches, development, and use of instructional learning strategies, including the use of teaching tools related to nanolearning and microlearning. Lastly, Mostrady et al. (2024) emphasized that microlearning is a flexible and highly effective approach to learning and it can be integrated into various digital tools like mobile apps, and e-learning platforms, including social media.

Keyword Co-occurrences Analysis

A co-occurrence analysis of keywords was conducted to identify the terms frequently used in research articles. Using the VOSviewer tool, the researcher set a threshold of two (2) as the minimum number of keyword occurrences. The analysis identified 21 items grouped into seven (7) clusters (Figure 6). Notably, the most dominant keyword is "microlearning," with 18 links, a total link strength of 33, and 26 occurrences. Additionally, terms such as "e-learning," "education," and "self-efficacy" were frequently used as keywords in the journal articles. As shown, the prominent orange circle highlights "microlearning" as the leading keyword used in the studies. This analysis is consistent with the findings of Mochamad (2024), who also identified "e-learning" and "microlearning" as the primary keywords used in the surveyed research articles from 2002 to 2023.

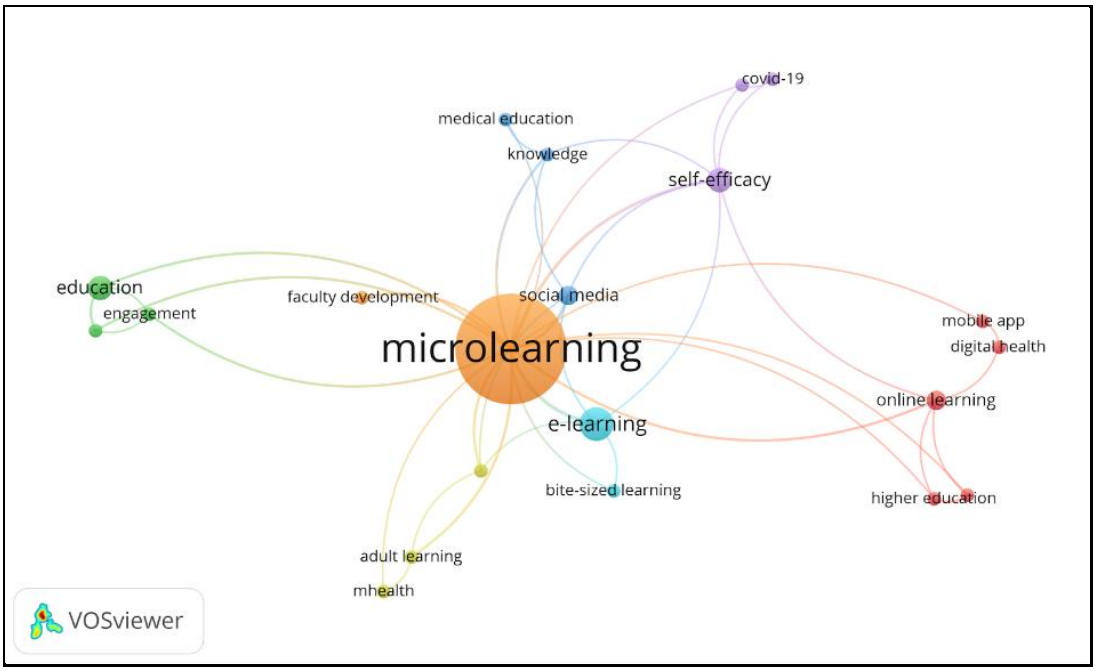

Figure 6. Network Visualization of Keyword Co-occurrences in the Publications

Co-authorship Analysis

According to Kumar (2015), co-authorship is regarded as an indicator of research collaboration and the mechanism that connects different scholars with a set of talents to generate research output and it can also be viewed through the lens of social networks. Moreover, the nodes in the co-authorship networks represent authors, countries, or organizations and these are connected when they share the authorship of a research paper. In this study, co-authorship visualization provides an overview of research collaboration in publications related to nanolearning and microlearning. Using VOSviewer, the parameter was set to a minimum of two (2) document occurrences, and the full counting method identified 19 authors distributed into two clusters, with 135 links and a total link strength of 156. As illustrated in Figure 7, Cluster 1 includes authors such as Kaduce, Bourn, Abraham, Calhoun, Uhl, Larmon, and Bregenzer. This cluster features 18 links, a total link strength of 24, and two associated documents. These findings indicate that there are instances of collaboration documented in the publications related to nanolearning and microlearning.

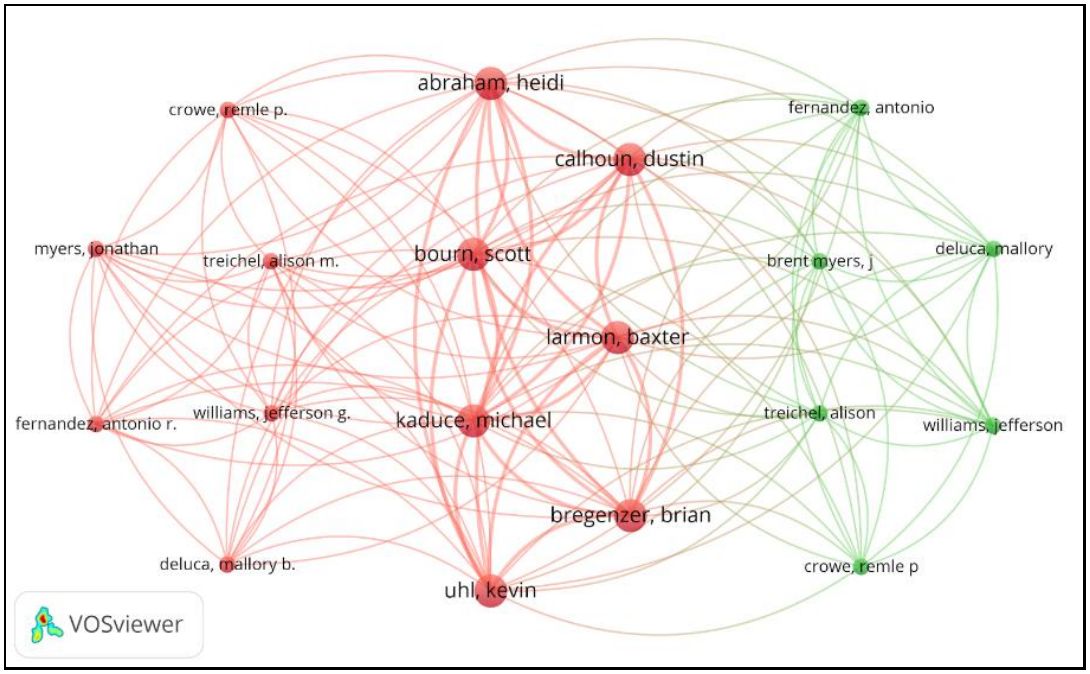

Figure 7. Co-authorship Network Visualization Analysis

Conclusion and Recommendations

This bibliometric analysis examined research publications on nanolearning and microlearning from 2020 to 2024 using the Lens Scholarly Search Database. The study analyzed the annual distribution of publications, most cited articles, leading journals, top publishers, dominant fields of study, top institutions, active authors, and active countries. Additionally, it visualized the emergent research themes based on data from titles, abstracts, keyword co-occurrences, and co-authorship networks. The results showed an increasing number of publications on microlearning across various fields, while nanolearning remains an emerging area with a lower publication count in the covered period.

Based on the findings three research themes were described: microlearning and nanolearning and its opportunities, which explores the potential and adaptability of microlearning, particularly in response to the challenges and opportunities caused by the pandemic. The second theme, research and evaluation, focuses on assessing the effectiveness and impact of these approaches across various contexts. Lastly, the third theme, applications and development, emphasizes practical uses and creative innovations aimed at enhancing the learning experience for both students and educators. Moreover, Indonesia ranked as the leading contributor in publication, followed by the United States. Microlearning and e-learning were the most frequently used keywords in the articles. Further, the analysis revealed active collaboration among authors on nanolearning and microlearning. This investigation provided essential data on the current state of knowledge on nanolearning and microlearning. A research gap in the use of nanolearning was observed in the investigation, therefore this study recommends that scholars explore nanolearning as a complementary approach to microlearning. Lastly, educators may utilize the publication of Yousef et al. (2023) to guide them on how to develop and implement nanolearning.

Limitations

Despite the promising results of the current bibliometric analysis, the researcher acknowledged several limitations of the study. Firstly, the articles were sourced exclusively from the Lens Scholarly Search Database. As this analysis was restricted to the studies available in the database, it is recommended that future research consider exploring multiple databases, such as Scopus, Web of Science (WoS), DOAJ, ACI, and others, to gain a broader understanding of research trends in the approaches. Secondly, some records were excluded due to the unavailability of full information within the database. Notably, some discarded articles had valuable insights into nanolearning and microlearning. Consequently, certain scholarly works may have been underestimated. Lastly, the database exhibited limitations in filtering certain crucial details for the analysis. The researcher observed that few of the scholarly works lacked tags for affiliation or institution, while others lacked tags for the field of study. These limitations may have influenced the accuracy of the counts for these specific variables.

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