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PAPER

Microlearning: Transforming Education with Bite-Sized Learning on the Go—Insights and Applications

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ABSTRACT

This research delves into microlearning, emphasizing its potential as a transformative tool in the digital age. It extends the theoretical foundations of microlearning, investigates evolving trends, provides practical examples, and discusses the implications associated with education. This is not only to contribute to the growing momentum of microlearning research but also to pave the way for future advancements. The study focuses on Scopus-indexed publications using a systematic review aligned with PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines and combined with bibliometric analysis. According to the analysis, there has been a noticeable increase in publications related to microlearning since 2015, highlighting a growing interest and contributions from scholars worldwide. The findings corroborate that microlearning is not just about providing learning material in small, easily digestible portions. Crucially, microlearning goes beyond the delivery of bite-sized content. Its flourishing research trajectory underscores its significance, especially for Generation Z and succeeding digitally native generations who are accustomed to smartphones, the Internet, and digital information. Hopefully, these findings offer valuable insights and serve as a reference for the education, government, business, and academic sectors to promote, design, and implement microlearning.

KEYWORDS

microlearning, bite-sized learning on the go, bibliometric, learning transformation, digital education trends

1 INTRODUCTION

Microlearning integrates two elements: “micro,” signifying small or minuscule, and “learning,” which refers to the process of acquiring knowledge or skills [1–3]. Essentially, microlearning encompasses learning activities that are performed on a small scale or within a limited time frame [4], [5]. Moreover, it constitutes an approach for structuring learning content into smaller, more precise segments [6], which may include learning objects used in e-learning [7]. Other terminologies used for microlearning include micro-learning, micro-eLearning, nano-learning,

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short-term learning, bite-sized learning, micro media, chunks, snacks, bursts, short courses, or micro-content [8], [9].

Microlearning implies delivering concise, bite-sized pieces of information to learners (Figure 1). These pieces are designed to be easily comprehensible and accessible anytime and anywhere. This approach is highly convenient for individuals with busy schedules. By breaking down complex topics into smaller components, microlearning promotes better retention and engagement among learners. Carla Torgeson has defined microlearning content as any form of learning that can be consumed within five minutes [10]. Such teaching methods distribute knowledge in smaller, concentrated bursts, encouraging the exchange of information and the application of learning. Microlearning courses should be as lengthy as necessary but as condensed as possible [11].

This learning methodology relies on the theory that the human brain processes and comprehends information more effectively when exposed to fast and concise content. Prolonged studying can cause learning fatigue, which varies among students. Educators should break down complex concepts into smaller components to avoid cognitive overload and student burnout syndrome. Microlearning is not entirely novel, as teaching tools like flashcards have been used for an extended period of time. Now, physical aids like books and papers have been replaced with electronic, digital, or online platforms [12], [13]. An internet-based learning management system facilitates the deployment of microlearning. However, extended and continuous exposure to electronic or digital media can entail adverse side effects. Consequently, microlearning provides an alternative approach to mitigate these effects while continuously fulfilling learning objectives and enhancing student competencies.

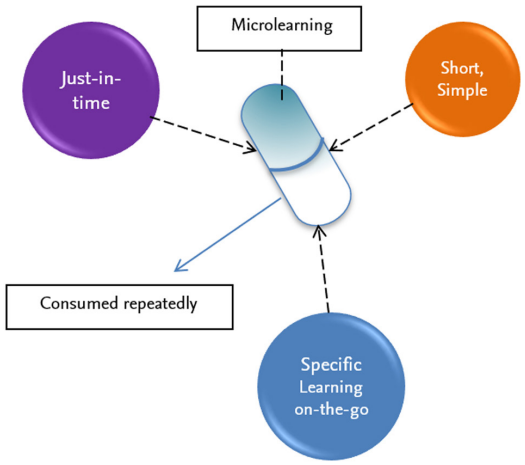


Fig. 1. Microlearning concept: Learning pills or Bite-sized learning on-the-go

Microlearning, as an instructional tool, innovatively addresses challenges related to memory retention and learning quality. It delivers content in concise bursts of 3–5 minutes, tailored to the needs of learners and focusing on specific learning objectives. By utilizing the forgetting curve and capitalizing on the effectiveness of spaced repetitions, microlearning provides learners with regular and targeted interactions with useful content. This method, which conveys information in easily understandable segments, not only ensures greater accessibility but also enhances understanding and retention. This approach aligns with contemporary research indicating that authentic learning experiences result in slower rates of forgetting. Further, microlearning aligns with the principles of meaningful learning, efficient information presentation, and strategies to counteract the impact of the forgetting curve.

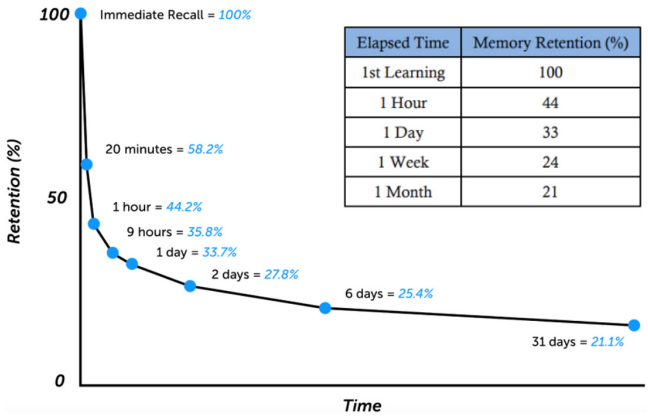
The primary purpose of this research is to provide a comprehensive overview of microlearning trends. Specifically, our aim is to highlight the implementation of microlearning, its potential benefits, and the challenges it faces. We also introduce an innovative method to enhance memory retention and improve the quality of learning. To accomplish this, we analyzed data from the Scopus database and utilized analytical tools such as R Studio and VOS Viewer. This unique study, renowned for its meticulous examination, covers nine dimensions: 1) annual scientific output, 2) annual citations per year, 3) most productive countries, 4) most relevant sources, 5) most notable authors, 6) authors' global impact, 7) most relevant affiliations, 8) most cited countries, and 9) word frequency analysis. These dimensions provide a multifaceted perspective, enabling us to explore the current state of microlearning, identify emerging trends, provide concrete examples, and address its educational implications. We aim to shed light on the role of microlearning in enhancing memory retention and improving the overall quality of learning.

In this study, we incorporated multiple viewpoints to offer a thorough and comprehensive understanding of microlearning research trends. We aim for our findings to benefit a diverse audience, including policymakers, educators, industry leaders, academics, and pioneers in microlearning. This holistic approach presents a comprehensive view of the evolving landscape of microlearning research.

2 CURVE OF FORGETTING

Learning is a continuous process, and as Hermann Ebbinghaus delineated in Figure 2, human memory tends to fade over time, as demonstrated by the "curve of forgetting." Generally, this phenomenon is caused by a lack of attention, the passage of time, or a desire to suppress a stressful event or distraction, whether it is psychological or physical [14], [15]. Kendra Cherry explains that forgetting is the loss of stored information from both short-term and long-term memory. This loss can be instantaneous or gradual [16], [17]. Psychologically, when information about the past is missing, it indicates that it is either no longer available or still present but inaccessible.

Ebbinghaus observed that the forgetting of new content is most rapid within the first 24 hours after learning (Figure 2), while the rate of loss gradually slows over time. He categorized the factors affecting the quality of initial learning into three categories: the meaningfulness of information, the method of presentation, and physiological factors such as stress, sleep, and hunger that can divert our attention.



Elapsed Time	Memory Retention (%)
1st Learning	100
1 Hour	44
1 Day	33
1 Week	24
1 Month	21

Fig. 2. Ebbinghaus curve or curve of forgetting

Interpretations of the "forgetting curve" in relation to the presentation of information vary. While engaging delivery methods are often considered more memorable for learning, cognitive load theory underscores the importance of minimizing unnecessary cognitive load. The key principle in education planning is to ensure the active engagement of students with the content. This is because, in order to learn, students need to actively think about the material. By designing tasks that focus on the content and minimize unnecessary cognitive load, students can concentrate more effectively on the material. It is important to remember that if a task exceeds the threshold of memorability, individuals may quickly forget the content, indicating an incomplete acquisition of the initial knowledge.

Physiological factors and distractions significantly impact memory retention. Deep engagement with significant events often leads to faster and more vivid recall. Distractions, such as hunger or environmental factors, have a lesser effect on the memory of important events. However, deliberately attempting to transform a lesson into a 'major event' to enhance memorability is not an optimal solution. Quality of thought heavily influences memory, and distractions can shift students' focus from the content to the distraction itself.

In memory research, the forgetting curve typically starts at 100% and progressively declines over time. However, it is essential to distinguish between the scope of learned information and the total extent of the instructional content delivered. Factors such as distractions and cognitive limitations during the learning process may result in a starting point below the expected 100% retention rate of the material being taught. This variation in starting points may explain the different levels of spelling recall observed among students, with some demonstrating limited retention while others exhibit thorough memorization.

Improving the quality of thought that students dedicate to learning content is crucial for enhancing memory retention. Ebbinghaus' findings suggest that reviewing information within a short period, ideally within 24 hours, offers two significant advantages. Firstly, it aids in consolidating acquired knowledge, starting with 100% retention. Secondly, it reduces the rate of information decay. The most effective strategy to reinforce memory and counteract the forgetting curve involves recalling information at progressively spaced intervals. Engaging in information recall helps refresh memory and slows down the rate of forgetting. Adhering to the "One Rule," students are advised to actively retrieve information within one hour, day, week, and month after initial instruction in order to maximize memory retention (see Figure 3).

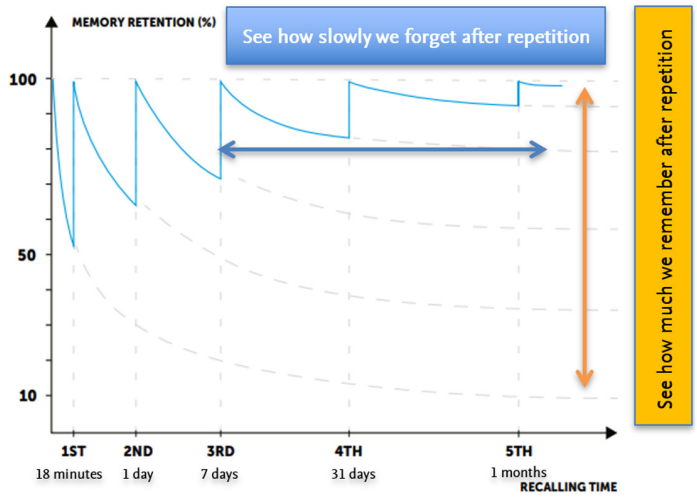


Fig. 3. Memory retention

This curve illustrates a decrease in the percentage of memory retention as the time elapsed from the initial learning of information increases. Microlearning can serve as an effective solution to overcome these challenges related to memory. The learning process involves dividing knowledge into smaller, easily digestible units, similar to a "learning pill" that encapsulates specific competencies. The inclusion of repetition is essential to enhancing the brain's ability to retain information. Achieving optimal retention requires spacing out repetition intervals appropriately. For near-perfect recall, experts recommend starting the initial repetitions within a few days.

3 METHODOLOGY

In this study, we adopted a systematic review approach coupled with bibliometric analysis to comprehensively encapsulate the most recent research methodologies on relevant topics or issues [8], [18–20]. We rigorously adhered to the preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines throughout the review process. This adherence guarantees a systematic, transparent, and replicable methodology in our review, thereby enhancing the reliability and precision of our findings. We used computer-assisted tools, such as R Studio and VOS Viewer, to analyze and visualize the data. These tools proved invaluable in identifying key research publications, recognizing prominent authors, and mapping out their intricate connections [21]. The entire process was iterative and dynamic, requiring multiple rounds of refinement to ensure accuracy. For a more detailed visualization of this process, refer to Figure 4.

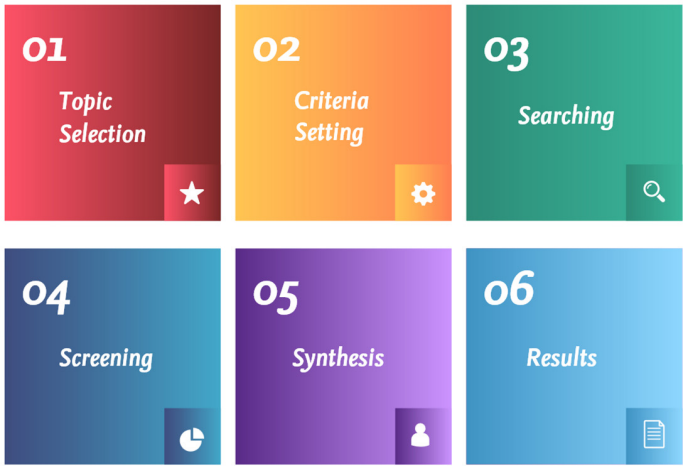


Fig. 4. Research procedure

In the initial phase of this study, we chose microlearning as the research focus. We applied several selection criteria to gather relevant data, including sourcing information from the Scopus database. We limited our data collection to publications spanning the past 13 years (2010–2022) and considered journals and conferences as acceptable forms of publication.

Furthermore, we used the search terms "microlearning" or "micro-learning" in keywords and titles to ensure that the relevant resources were included. These selection criteria were instrumental in laying the foundation for our comprehensive exploration of microlearning. To ensure the validity of the dataset and to comply with the standard criteria, we eliminated any duplicate entries. Through analysis, we identified trends and discussed the implications of microlearning, which led to our

conclusions. Lastly, we reported on and deliberated upon the results, drawing conclusions and offering recommendations that aligned with the findings.

4 RESULTS AND DISCUSSION

We identified 126 articles using the specified keyword parameters and the article title "Microlearning." A screening process was conducted to ensure the inclusion of only high-quality publications. We focused on Scopus-indexed journals and conference papers published between 2010 and 2022.

4.1 Annual scientific production: documents

A total of 80 publications were identified and subjected to thorough analysis. These sources comprised 75 distinct journals and conferences published by various esteemed publishers, featuring 218 authors. The outcomes of the preliminary data processing are depicted in Figure 5, which provides an overview of the study's progress. A more detailed analysis of the observed publication trends is shown in Figure 5. Before 2014, there was no noticeable upward trend in the number of published articles. However, since 2015, there has been steady and significant growth in the number of published papers, with peak numbers being reached in 2020 and 2021. This upward trend corresponded to an average annual growth rate of 3.44%.

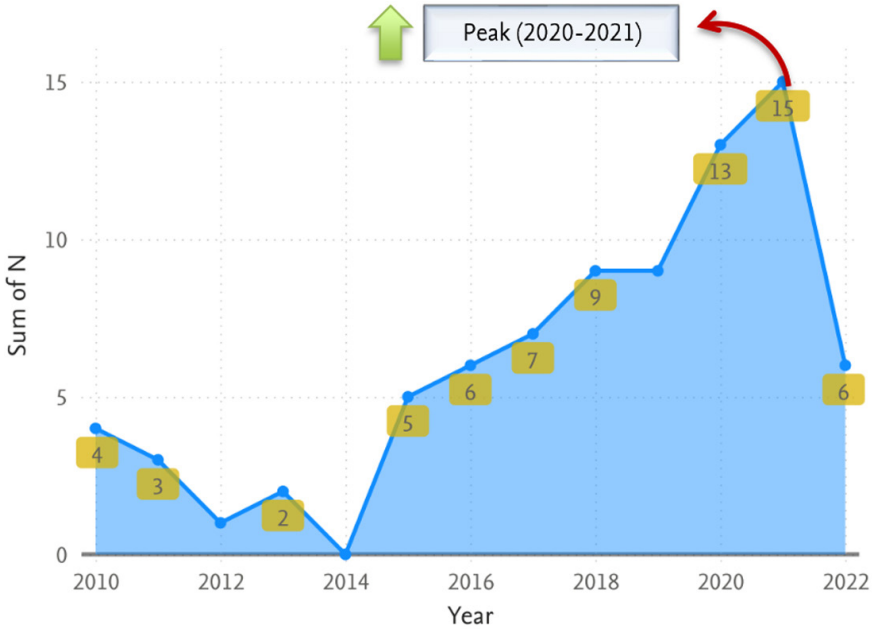


Fig. 5. The highest numbers occurred in 2020 and 2021

These findings demonstrate growing academic interest in microlearning, as evidenced by the increasing number of publications in recent years. Such growth suggests the recognition of the significance and relevance of microlearning within a broader educational context. The availability of a larger body of research contributes to the expansion of knowledge and informs the development of innovative models, methodologies, and media formats in microlearning.

4.2 Annual citations per year

Based on the data in Figure 6, we observed the annual average of citations per year across different metrics. These metrics include the number of articles published (denoted as "N"), the average total citations per article (represented by "mean TC per art"), and the average total citations per year (indicated as "mean TC per year"). Notably, 2021 stood out with the highest citation count, averaging 4.40 mean TC per year. In addition, we identified significant peaks in citations during both 2018 and 2021.

From these findings, we can deduce the impact of the COVID-19 pandemic. The surge in research activities and focus on microlearning, which can be attributed to the pandemic, has led to an increase in citation count in 2021. The disruptions resulting from COVID-19, which necessitated the widespread adoption of remote and online learning, likely sparked greater interest and exploration into the practicality of microlearning as a viable educational strategy.

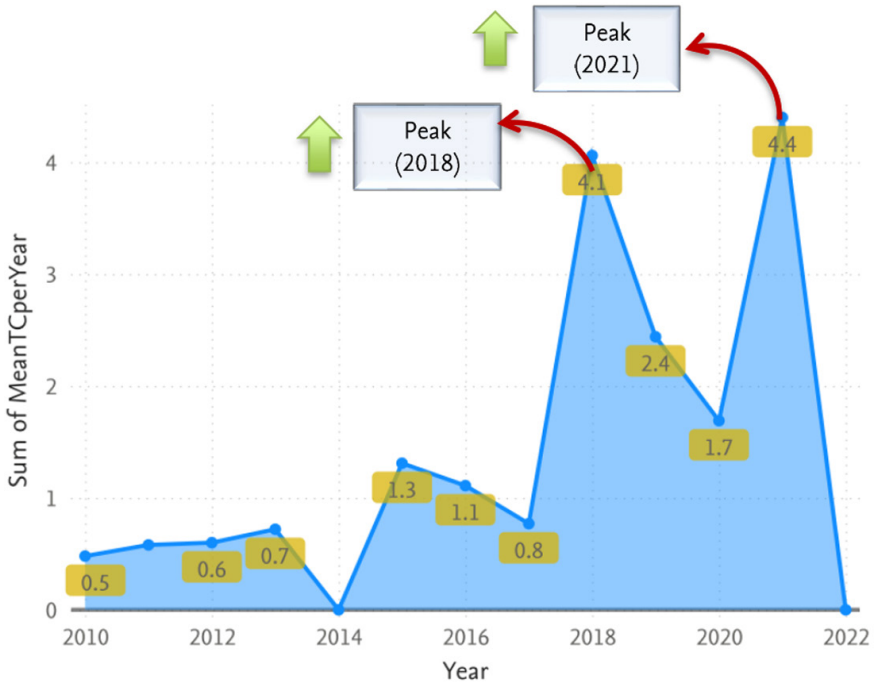


Fig. 6. Annual citations per year

Similarly, the peak in citations in 2018 might suggest a growing recognition of the significance of microlearning in the years prior to the pandemic. The connection between these citation peaks and global events surrounding COVID-19 suggests that microlearning has garnered significant attention and academic interest as an effective educational response during times of crisis and remote learning.

4.3 Most production countries

In Figures 7–9, we analyzed the dataset by creating a three-dimensional plot based on the parameters of the authors, countries, and keywords. It is significant to note that Australia led in the number of publications, followed by China, the United Kingdom, the United States, and Germany. These findings suggest that researchers and scholars from Australia have actively participated in the field of microlearning,

with significant contributions also coming from China, the United Kingdom, the United States, and Germany.

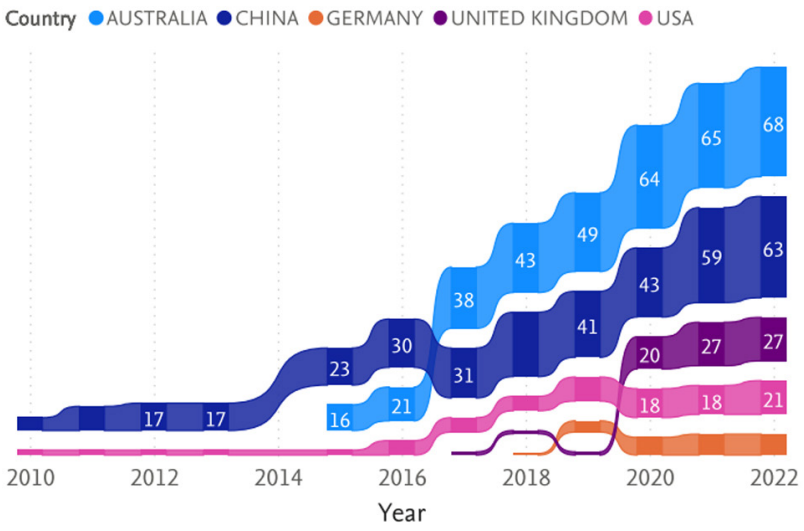


Fig. 7. Countries' production trends over time

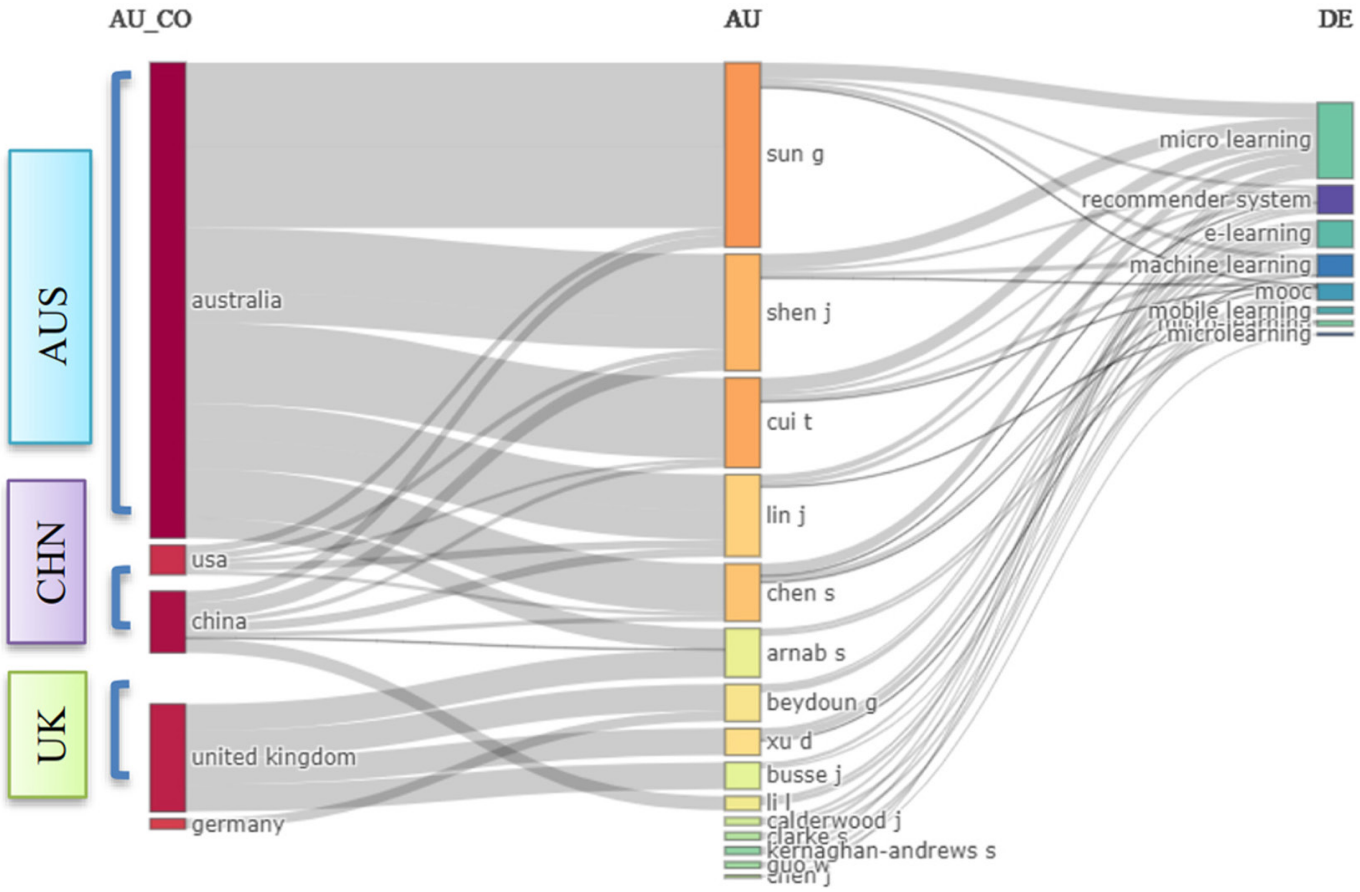


Fig. 8. Three-field plot: authors, countries, and keywords of the top three countries

Australia, China, the UK, the US, and Germany stand out from other countries when it comes to publishing articles about microlearning due to several key factors.

These countries possess robust research and education systems, with well-established universities and institutions dedicated to educational research and innovation. The technological advancements and investments in digital innovation made by these schools have played a crucial role in integrating technology into education, including the implementation of microlearning practices. Additionally, these countries have fostered extensive domestic and international academic collaborations and networks. This connectivity enables researchers to collaborate on microlearning projects while contributing to an ever-expanding body of literature.

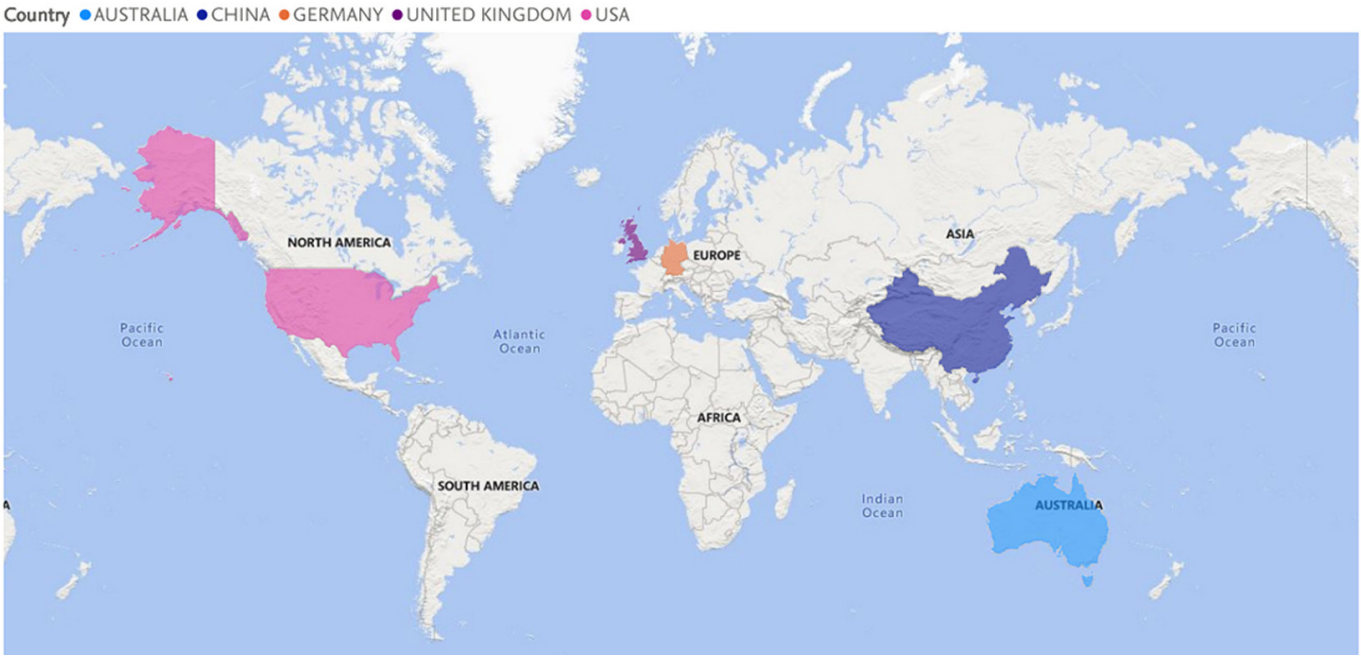


Fig. 9. Country scientific production: Australia and China

Additionally, significant funding opportunities and recognition of the increasing significance of microlearning in addressing digital societies have motivated researchers in these countries to explore and publish studies in this field. However, it is crucial to note that research on microlearning extends beyond specific regions and attracts global scholarly interest and participation.

4.4 Most relevant sources

Table 2 illustrates the distribution of articles across various sources. The data indicates that multiple sources, including the *ACM International Conference Proceeding Series*, *BMC Medical Education*, *Education, and Information Technologies*, *IEEE Global Engineering Education Conference* (EDUCON), and the *International Journal of Emerging Technologies in Learning* (iJET), have each published two papers. Moreover, several conferences and symposia are represented with single papers each, such as the *International Conference on Advances in Computing, Control, and Telecommunication Technologies* (ACT), the *International Conference on Electronics Computer and Computation* (ICECCO), the *International Symposium on Knowledge Acquisition and Modeling* (KAM), the *International Conference on Artificial Intelligence, Management Science, and Electronic Commerce* (AIMSEC), and the *International Conference on Electrical and Control Engineering* (ICECE) [22], [24].

Table 1. 10 Most relevant publication sources

No.	Sources	Articles
1.	ACM International Conference Proceeding Series	2
2.	BMC Medical Education	2
3.	Education and Information Technologies	2
4.	IEEE Global Engineering Education Conference (EDUCON)	2
5.	International Journal of Emerging Technologies in Learning	2
6.	International Conference on Advances in Computing, Control, and Telecommunication Technologies (ACT)	1
7.	International Conference on Electronics Computer and Computation (ICECCO)	1
8.	International Symposium on Knowledge Acquisition and Modeling (KAM)	1
9.	International Conference on Artificial Intelligence, Management Science and Electronic Commerce (AIMSEC)	1
10.	International Conference on Electrical and Control Engineering (ICECE)	1

This data demonstrates that many sources recognize the significance of microlearning, as illustrated by the considerable number of published articles. The inclusion of conferences and symposia suggests that microlearning is a prominent topic in academic discourse. The wide distribution of articles across various platforms highlights the diverse forums that researchers use to share their insights, promoting knowledge sharing and advancing the field of microlearning.

4.5 Most relevant authors

Based on Figure 10, Sun G. emerges as the most prolific author with 12 documents, closely followed by Cui T. and Shen J., each with 11 documents. Chen S., with nine documents, also ranks among the top 25 most relevant authors with the highest number of publications.

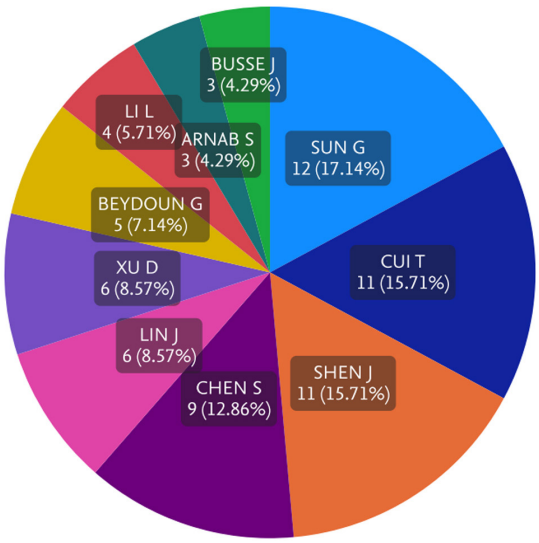


Fig. 10. Most relevant authors by a total of documents

Sun G., the author of 12 published documents, has made significant contributions to microlearning. His research encompasses various aspects of this field, such as instructional design, pedagogical approaches, technological implementation, or the effectiveness of learning. His extensive body of work demonstrates a profound commitment and expertise in microlearning, delving into a diverse array of subjects to enhance knowledge and comprehension in this area. Cui T., Shen J., and Chen S. are also among the 25 most relevant authors, with 11 and 9 documents, respectively, in the research of microlearning, marking important contributions. These authors discussed topics and perspectives related to microlearning practices and their implications in various educational settings. Additionally, their extensive publication record demonstrates their commitment to expanding the knowledge base in this field and sharing valuable insights with scholarly communities worldwide.

Although this scenario does not provide specific details about their research activities, the documents authored by these individuals make significant contributions to the research and practice of microlearning. Their work enhances our understanding of the theoretical foundations, practical applications, and potential effects on learning outcomes. Both researchers and practitioners can derive immense value from the work of these authors. This can serve as a source of inspiration for further exploration, inform instructional design decisions, and foster innovative practices in microlearning.

4.6 Author's global impact

The document titled "Mobile-Based Micro-Learning and Assessment: Impact on Learning Performance and Motivation of High School Students" by NIKOU SA is globally the most-cited. It emphasizes the potential of mobile learning to enhance learning and motivation, making it an effective training approach in work-based and corporate environments. The document also presents mobile learning as a suitable mechanism for delivering microlearning and micro-assessment, which has significant implications for the future of education and training. This document has undoubtedly had a significant impact on the field of education, with a total citation count of 69 and yearly average of 11. It continues to inspire further research and development (see Table 2).

Table 2. 10-most globally cited documents

Paper	DOI	TC	TC Per Year
NIKOU SA, 2018	10.1111/jcal.12240	69	11.50
DESSÌ D, 2019	10.1016/j.chb.2018.03.004	48	9.60
SUN G, 2018	10.1109/tsc.2015.2473854	43	7.17
YIN J, 2021	10.1177/0735633120952067	26	8.67
DÍAZ REDONDO RP, 2021	10.1007/s11042-020-09523-z	22	7.33
PARK Y, 2018	10.18517/ijaseit.8.1.2698	20	3.33
ZHAO Q, 2016	10.1109/cit.2016.47	17	2.13
SUN G, 2015	10.1109/mobserv.2015.26	15	1.67
SUN G, 2015	10.1109/cscwd.2015.7230977	13	1.44
LIN J, 2020	10.1007/s11280-019-00730-9	11	2.75

Figures 11–12 reveal that the ten most-cited authors have received the highest number of citations. Sun G. holds the leading position with 120 citations, closely followed by Cui T. (118 citations), Shen J. (118 citations), and Chen S. (112 citations). In the realm of collaboration, China and Australia are dominant forces.

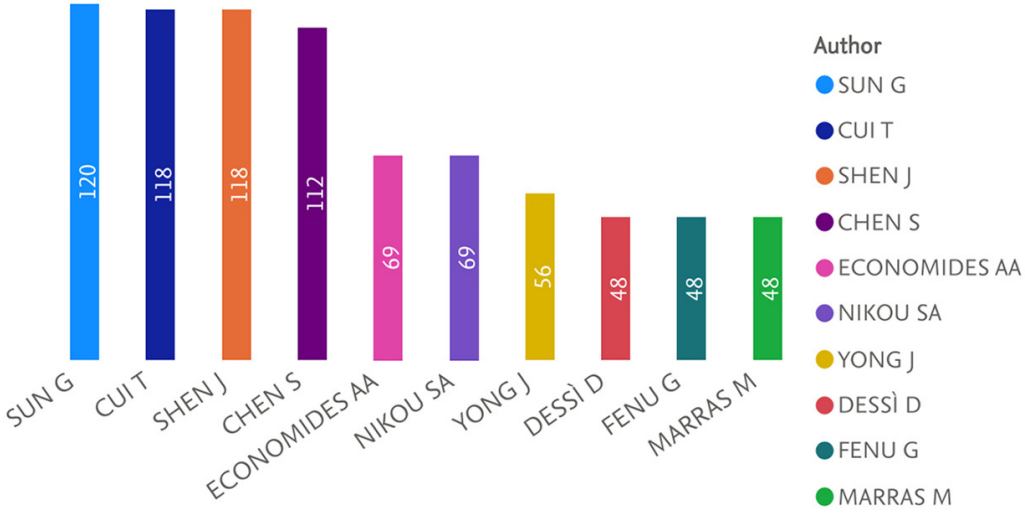


Fig. 11. Top 10: most-cited authors by a total of citations

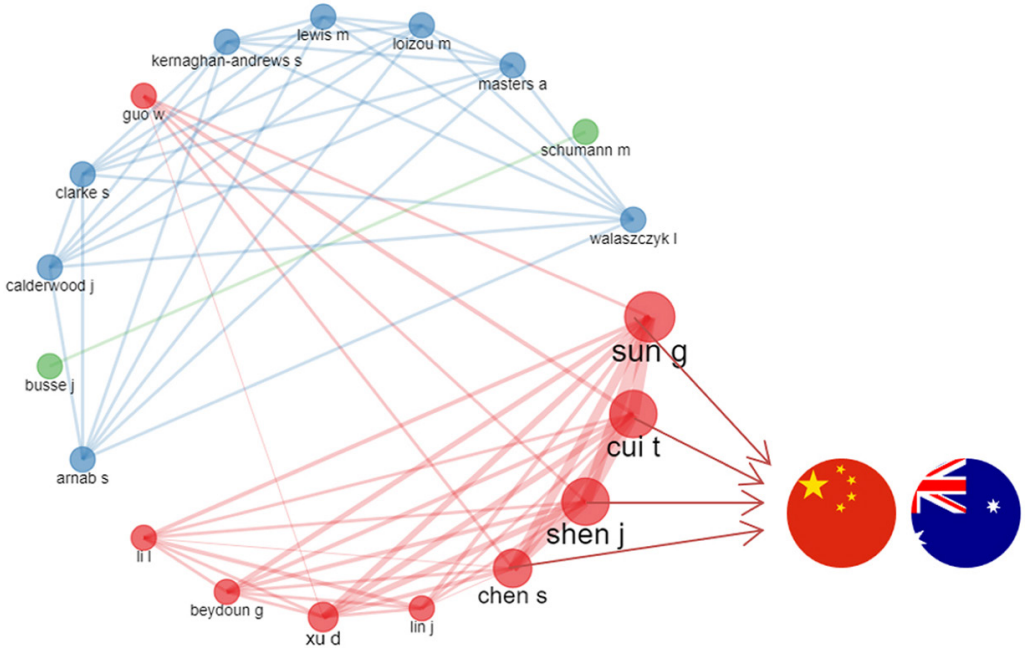


Fig. 12. Collaboration networks

4.7 Most relevant affiliations

As evident from Figure 13, the five most prominent affiliations with the highest number of documents on microlearning are the University of Wollongong (with eight documents), Coventry University (with six papers), Henan University of Science and Technology (with six documents), and Beijing Normal University (with five articles).

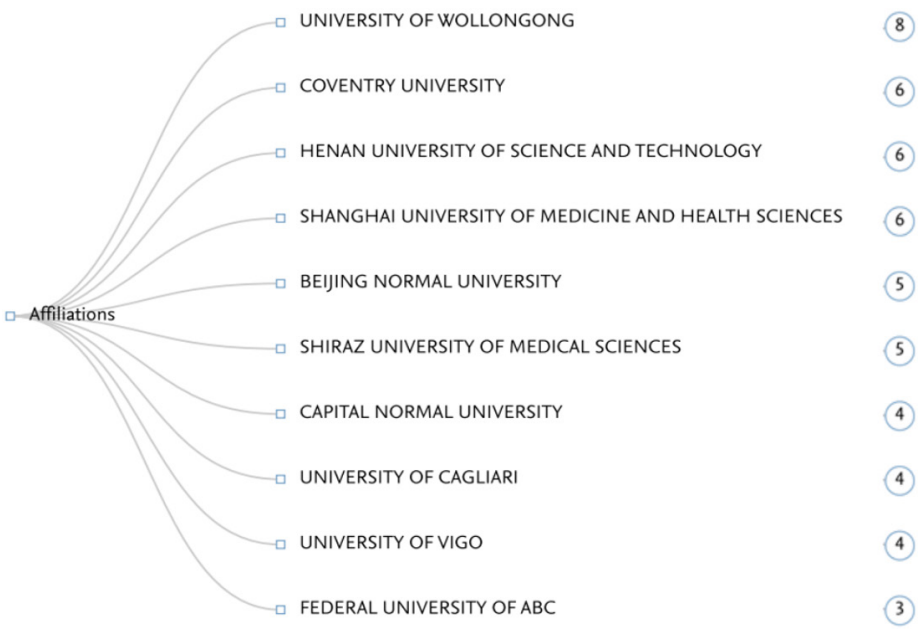


Fig. 13. Top five: most relevant affiliations

4.8 Most cited countries

As shown in Figure 14, Greece is the leading country in terms of citations, with 69 citations. China follows closely with 57 citations, while Italy has 48 citations and Spain has 22 citations.

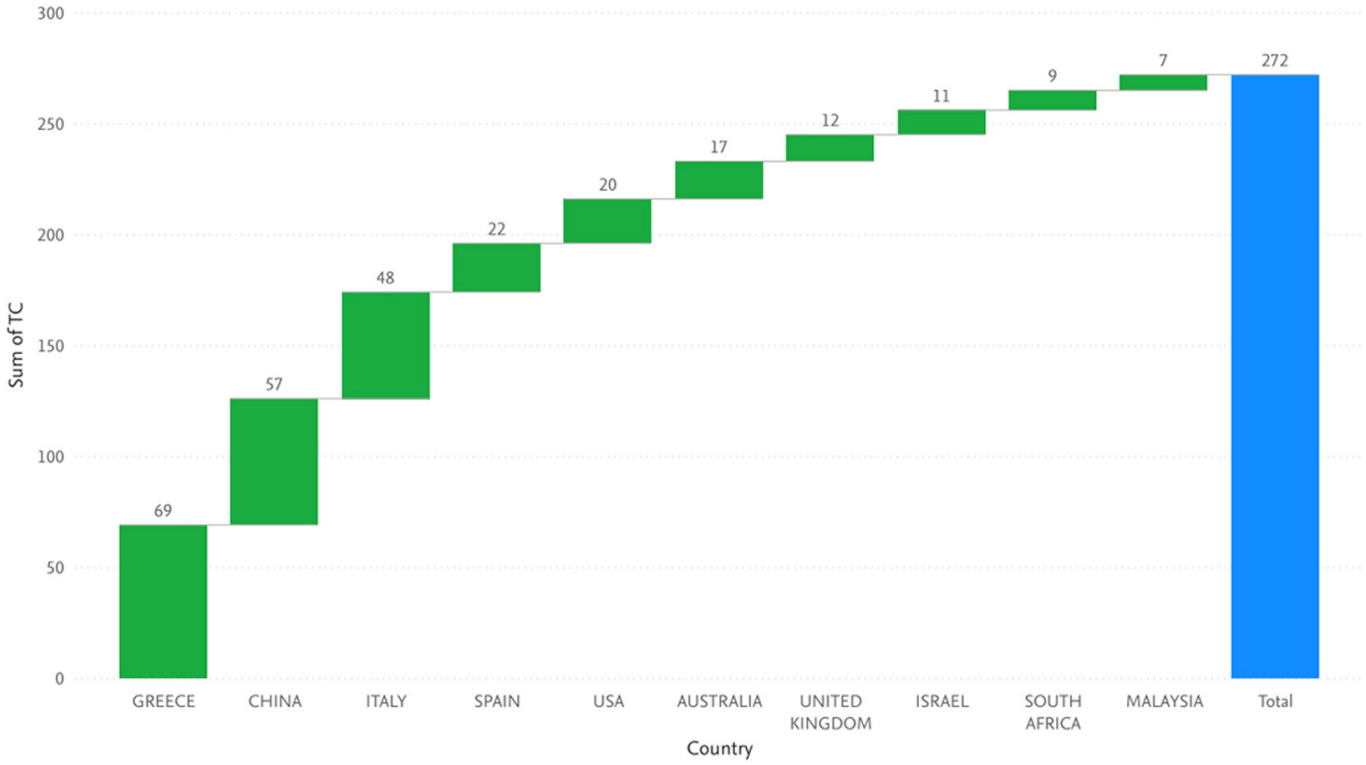


Fig. 14. Top 10: most-cited countries

4.9 Word frequency analysis

As illustrated in Figure 15, the most frequently used keywords were micro-learning (29%), followed by e-learning (18%), and mobile learning (5%).

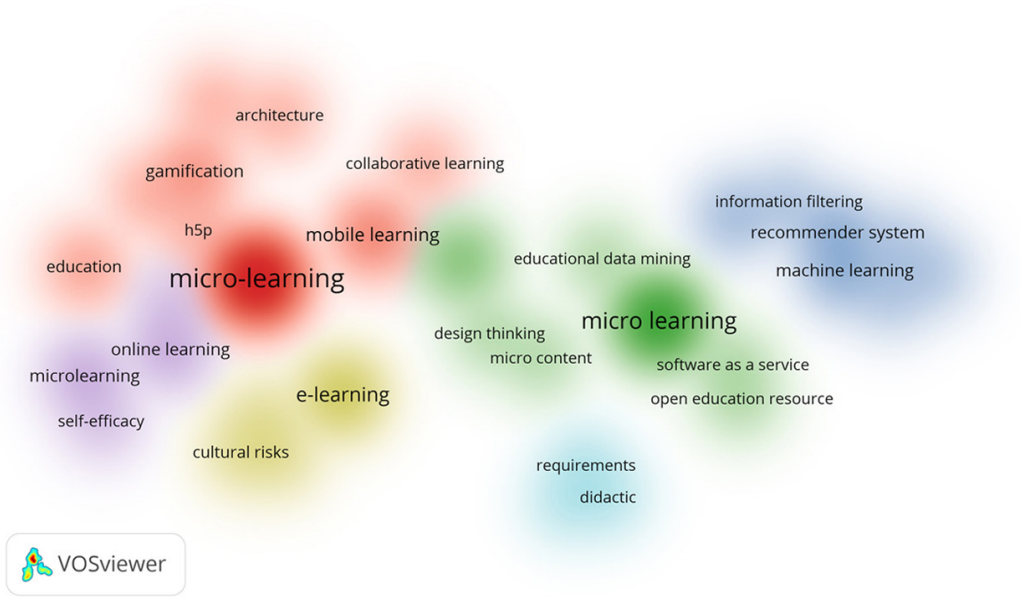


Fig. 15. Density visualization: most frequent keywords

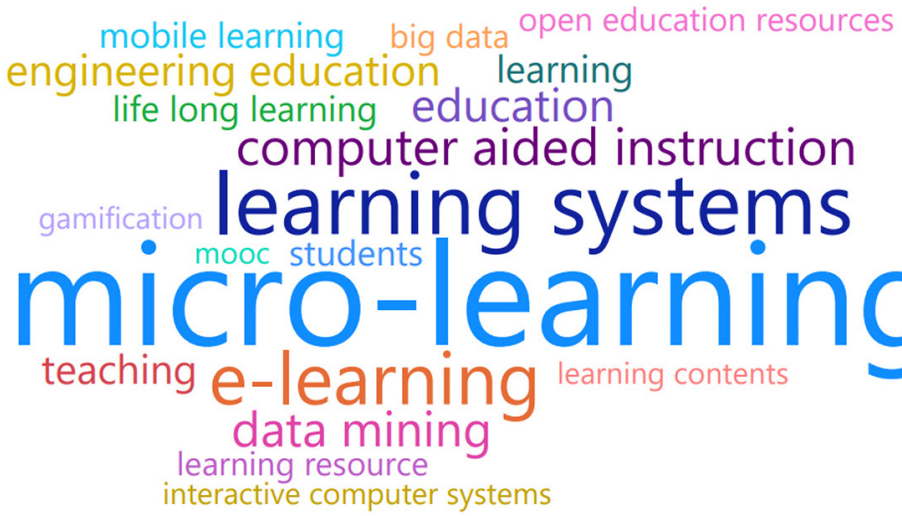


Fig. 16. Wordcloud: most frequent keywords

Using VOS Viewer, we identified associations between microlearning and various learning models and media, such as mobile learning, H5P, gamification, online learning, and open educational resources [23]. A word cloud generated using R Studio, depicted in Figure 16, also reflects this trend. It reveals strong correlations among microlearning, e-learning systems, and educational environments, indicating the significance of microlearning in designing these environments for educational use. Research on microlearning has primarily focused on engineering education. Microlearning models, such as gamification, MOOCs, and mobile learning,

have become increasingly popular, highlighting their positive impact on the quality of content and resources for online learners. Microlearning offers concise, easily digestible lessons that engage and reinforce learning. Microlearning enhances overall learning processes, making them more accessible and efficient.

4.10 Discussion

The visualization of the bibliometric analysis results using R Studio and VOS Viewer revealed that Australia and China made the most significant contributions to articles related to micro-learning. This is a departure from the usual trend, where the United States leads in many other fields. Interestingly, microlearning has received a wide range of contributions from various authors, with Sun G. being the most prolific. Sun G. has published 12 articles on the topic and has received 120 citations. Following a review of 80 articles, this paper focuses on some intriguing aspects, specifically examining examples of learning objects that are suitable for microlearning. These learning objects can include various types of multimedia, such as animation technology, GIFs, infographics, social media, job aids, simulations, e-books, quizzes, audio, images, mobile apps, flip-books, broadcasts, games [25], [26], videos, digital flashcards, mind maps, whiteboards with animation, and blogs, among others [27].

The review results highlighted differences between microlearning and mobile learning. Although microlearning often follows a mobile format, it focuses on a single learning objective. In contrast, mobile learning aims to support learners engaged in on-the-go learning, as mobile devices are ideal for accessing micro-content [28–30]. Learners can interact with small pieces of content on the go without having to focus on a single learning objective [34]. Compared with traditional learning methods [31], which are more time-consuming and easily distract students, microlearning has proven to be more effective. It can help students maintain focus while studying because of its short, concise, and explicit content, which does not compromise understanding and retention of the learning material [32].

The practical approaches encompassed by microlearning for delivering bite-sized and targeted learning experiences are diverse. Examples include microcopy, which offers learners short and contextual aid messages, and microlearning videos that provide concentrated content for specific learning outcomes. These videos can be standalone learning nuggets or integrated within longer learning paths [33]. Mobile apps have become essential tools for on-the-go micro-lessons, with platforms like YouTube and Google offering easily accessible microlearning content [34]. Elements of gamification, such as scoring, awards, and badges, are present in micro-challenges and games [35]. These elements encourage active participation and create a sense of achievement among learners [36]. Effective microlearning strategies include multiple-choice quizzes, polls, flashcards, simulations, and learner recordings, all of which enhance engagement and knowledge retention [37]. Infographics offer visually stimulating representations of information, aiding in the comprehension of complex concepts and enhancing knowledge retention. Furthermore, social media platforms provide additional microlearning opportunities through activities such as microblogging and content subscriptions. This fosters knowledge exchange and collaboration within online practice communities. These examples show how technology, when combined with learner-centric strategies, fosters engagement in microlearning experiences that enhance educational impact, engage learners, promote knowledge retention, and effectively apply acquired skills.

Microlearning is not merely a method of presenting material in a short form; it is also an effective way to enhance learning outcomes [37], [38]. Microlearning's attractive format is known to enhance focus and minimize distractions. Currently, the delivery of educational material relies heavily on videos because of their effectiveness as an educational medium. Videos facilitate effective communication of lessons from instructors to their students. As images are processed faster by the human brain compared to text, they are more accessible and easier to comprehend. The seven benefits of microlearning are illustrated in Figure 17.

Fig. 17. The seven benefits of microlearning

1. **Speed to Knowledge:** Microlearning enables individuals to acquire the information they need, when they need it, by providing on-demand access for testing and learning purposes. This concept of rapid knowledge access refers to the ability to quickly and efficiently obtain necessary information or skills exactly when they are needed. It allows for immediate access to specific snippets of data or concepts, ultimately saving both time and effort.
2. **Improves Completion:** Microlearning programs, which deliver content in smaller, focused units, have shown higher completion rates compared to traditional training methods. The bite-sized format of their content simplifies learning for learners, leading to more efficient engagement with the material and ultimately increasing motivation. This is advantageous for individuals who struggle to complete lengthy training courses.
3. **Brain-friendly:** Microlearning aids in reducing cognitive load and enhancing focus by segmenting information into manageable chunks for learners to easily digest. This approach aligns with how our brains naturally function. Given our limited attention spans, which are often overwhelmed by massive volumes of material, microlearning's manageable size supports better material retention [4].
4. **Anywhere and anytime:** Digital channels have revolutionized learning by making educational resources accessible from any location at any time, providing convenient learning opportunities during commutes, travel time, or breaks. This facilitates the acquisition of knowledge precisely when it is beneficial or when experimenting with new approaches [39].
5. **Aligned with Gen Z lifestyle:** Microlearning considers the modern, fast-paced world and how people access information. It recognizes that individuals typically access information through various digital devices such as smartphones, tablets, or laptops. By catering to our preferred methods of consuming information, microlearning can enhance learning experiences [40–43].

6. **Self-directed learning:** Microlearning empowers learners by offering them choices in their education, which triggers a reward response in the brain, enhancing motivation and engagement. Individuals who take control of their learning journey are likely to retain and apply content more effectively. As self-directed learning fosters ownership and personalization, it results in more impactful experiences for both the teacher and learner.
7. **Supports peer-to-peer learning:** The bite-sized format of microlearning facilitates peer-to-peer learning, making content easily shareable among learners. This promotes active engagement and exchange of diverse perspectives, ultimately enhancing the learning experience. Learners can easily share modules, insights, and knowledge, which promotes greater engagement. Given its bite-size nature, microlearning is more accessible than ever for sharing specific information.

5 CONCLUSIONS

The dynamics of microlearning, as illustrated through a comprehensive bibliometric analysis and review of 80 articles, offer a new perspective on contemporary educational practices, with countries such as Australia and China leading the way in microlearning research. The significant contributions from authors such as Sun G., along with the wide variety of learning objects compatible with microlearning, ranging from infographics to digital flashcards, underscore the versatility and adaptability of this learning methodology. Differentiating between microlearning and mobile learning is crucial for understanding today's nuanced educational strategies. While both capitalize on brevity, microlearning prioritizes a single learning goal, unlike mobile learning, which provides flexibility in engaging with content. One notable advantage of microlearning is its efficiency. Unlike conventional learning, which can become lengthy and distracting, microlearning's concise nature ensures focused attention and comprehension.

Numerous tools and strategies contribute to the success of microlearning. The variety ensures that learners have multiple avenues for assimilating knowledge, whether through microcopy, micro-learning videos, mobile apps, gamified experiences, or engaging infographics. The role of videos is particularly noteworthy, as they leverage the brain's inclination for visual information processing to make content more digestible. Microlearning consists of more than just placing learning materials online or offering learning experiences in bite-sized chunks. Its primary goal is to identify essential application points and bridge any performance gaps identified during its delivery. Presenting learning content in bite-sized increments caters to the needs of learners, keeping pace with technological advancements. Microlearning proves highly advantageous with its small, easy-to-grasp learning units, providing learners with access to content anytime, anywhere. Instructional design should prioritize providing concise learning solutions in order to achieve the desired results. However, modern learners prefer easily digestible learning modules that are available 24/7, making microlearning only occasionally suitable for mastering complex skills that require more than a week of continuous content or for pursuing long-term performance objectives.

Microlearning delivers content efficiently, offering readily accessible bites of information day or night. E-learning through microlearning is viewed as a practical solution, thanks to its four primary characteristics: bite-sized learning, targeted delivery, short-term goals, and flexibility. With technological advancements, Generation Z and future generations have access to mobile phones, Internet, and enormous amounts of data. This has paved the way for social networks and information-sharing platforms such as WhatsApp or YouTube, as well as custom-made data products. These changes have

made the current generations highly informed, eager to learn, and eager to progress. By 2019, Millennials were expected to surpass Baby Boomers as the largest living adult generation. By 2025, they are expected to constitute 75% of the workforce. It is crucial to acknowledge and value the age diversity present in the workforce, which makes microlearning an attractive option for the technologically adept younger generation. The results of this study have revealed an upward trend in publications on microlearning since 2015. Various authors have contributed their expertise to this subject matter, thereby sustaining the momentum within microlearning research. Microlearning represents a forward-looking strategy that optimally combines technology, psychology, and pedagogy.

6 AUTHOR CONTRIBUTIONS

Agariadne Dwinggo Samala: Conceptualization, Methodology, Software, Formal Analysis, Data Visualization, Supervision, Writing—original draft, Writing—review and editing. **Ljubisa Bojic:** Formal Analysis, Validation, Writing—review and editing. **Derya Bekiroğlu:** Formal Analysis, Validation, Writing—review and editing. **Ronal Watrianthos:** Resources, Screening, Validation. **Yeka Hendriyani:** Screening, Validation.

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