Acta Pedagogia Asiana

Review
Volume 4(1), 2025, 33–42
https://doi.org/10.53623/apga.v4i1.496

Microlearning and its Effectiveness in Modern Education: A Mini Review

Ahmed Mostrady[1]*, Eva Sanchez-Lopez[2], Andres Filipe Gonzalez-Sanchez[3]

[1]School of Education, State University of Zanzibar, Vuga Rd, Zanzibar, Tanzania
[2]School of Philosophy and Pedagogy, Universidad Central del Ecuador, Av. Universitaria, Quito 170129, Ecuador
[3]Faculty of Education, Universidad de Antioquia, Medellin, Colombia

*Correspondence: ahmedmostrady@gmail.com

SUBMITTED: 16 September 2024; REVISED: 4 November 2024; ACCEPTED: 6 November 2024

ABSTRACT: The modern educational environment is increasingly moving toward using innovative teaching approaches. One such approach is microlearning, which is characterized by delivering small, focused portions of information that can be quickly consumed and easily retained. Microlearning fits well within the context of digitized education. Its flexibility and adaptability make it a good match for the kinds of short, attention-limited spans that today's learners tend to have. This review will look at the concept of microlearning, the technological platforms that can be used for it, and the effectiveness of microlearning for improving learning outcomes. Several studies have shown that microlearning improves knowledge retention, lowers cognitive load, and allows learners to consume content at their own pace. These studies have established microlearning as a highly effective and flexible modern pedagogical practice. The dissemination of microlearning is now largely in the hands of digital tools—mobile apps, e-learning platforms, and social media—making it more accessible and convenient than ever before. In conclusion, microlearning presents a promising model for modern education, offering substantial cognitive benefits when applied effectively. However, it is essential to balance its use with more in-depth learning strategies to ensure comprehensive understanding.

KEYWORDS: Microlearning; cognitive load theory; knowledge retention; E-learning platforms; digital education

1. Introduction

Microlearning is an educational method that conveys information in very small segments. It is designed to allow the learner to grasp the information almost instantaneously and remember it for a sustained period. When one thinks of microlearning, one usually thinks of the short, mobile devices—this is because microlearning is often delivered in these formats. Mobile devices and e-learning platforms allow the user to access short snippets of content anywhere, anytime [1, 2]. Presenting content in small, easily digestible pieces allows learners to focus on a single idea, thereby reducing cognitive load and enhancing retention. This approach conforms with the theory of cognitive load, which holds that the brain can only process a certain amount of information at one time. The practice of "microlearning," as it moves strongly in this direction and places strong emphasis on teaching through the use of practical (as opposed to

merely theoretical) situations, is good for teaching supposedly low-level skills. These are skills that must be learned quickly and applied in immediate, somewhat superficial, practical situations. "Microlearning" contrasts sharply with traditional methods that may waste time teaching (in a classroom) or imposing a rigid curriculum on students [3, 4].

Content is available to learners anytime and anywhere, allowing them to study at their own pace. This model of education fulfills the demands of modern life and is especially suited to those who are trying to carry on some work or life semblance in a shared society. In contrast to the typical learning day, which is segmented into hour-long blocks, microlearning allows the professional, the father, the mother, the student, or anyone else to learn in very small increments [5, 6]. This review explores the concept of microlearning, its technological platforms, and the effectiveness of microlearning in improving learning outcomes.

2. Technological Platforms for Microlearning.

he effectiveness and flexibility of microlearning have made it an increasingly popular educational approach. This newfound popularity is certainly due in part to the many digital tools and platforms available for use today. Educators can use these methods to deliver not just lessons considered "bread" in the provision of knowledge—lessons that by necessity tend to be somewhat linear and long—but also to deliver "circumstances" in which students can encounter knowledge, or what we might term "teachable moments." And not just any teachable moments will do; among the targets of microlearning are moments in which content is more likely to be retained because it has been delivered at the right time and in the right way [7, 8].

The learning world has also embraced microlearning, and mobile applications are among the most popular formats. They allow learners to access content anytime and anywhere and to engage with it in brief, interactive ways. Most people live such busy lives that finding time to focus on and truly absorb material often just does not happen. Enter the mobile app, which grants you permission to learn in short and sweet moments throughout your day—whether you are waiting in line, sitting on a bus or subway, or taking a break from your otherwise task-filled schedule. The limbic system—the part of your brain that governs emotions and motivation—gets involved when you see something that piques your interest in these apps during free moments. Duolingo and Quizlet are good examples of microlearning platforms that function as apps, but you can also find microlearning in right-sized, short-nosed approaches to other platforms, like LinkedIn Learning [9–11].

Microlearning is also being embraced by e-learning platforms in their offerings. Platforms such as Coursera, Udemy, skills-led and LinkedIn Learning provide a range of courses that can be broken down into shorter segments or "modules." This allows both leaners and teachers a new level of course design flexibility... This accessibility of e-learning platforms also puts high-quality content available to a considerable number of learners globally [12, 13]. The main purpose of social media is still communication and entertainment, but in recent years, powerful microlearning platforms have also emerged from among the actual educational tools. YouTube, Instagram, and TikTok are now being used for educational purposes in ways that range from the informal to the more formal end of the spectrum, with even lectures in some cases. In these three cases, you're looking in each instance at a very different atmosphere, as well as a very different kind of audience that an educator might be reaching. On YouTube, for example, there's much more of a scholarly atmosphere—you can even subscribe to a channel like "Crash Course" and have access to a full term's worth of content, in effect, a course. On

Instagram (yes, you can find educational content here) and TikTok, you're in much more of a casual context [15, 16].

These digital tools— mobile apps, e-learning platforms, and social media— have come together nicely to make microlearning a commonly accepted educational strategy. They are, by their very nature, conduits of short and discrete messages. They are also platforms for not just content but for connections — the first step in the classroom of the future. Not by accident, these are also technologies in which tomorrow's students are thoroughly immersed. Hence the appeal to thinkers in academia and industry of an awful lot of research being put forth under the guise of "the 4 Cs" (creativity, communication, collaboration, and critical thinking). [16, 17].

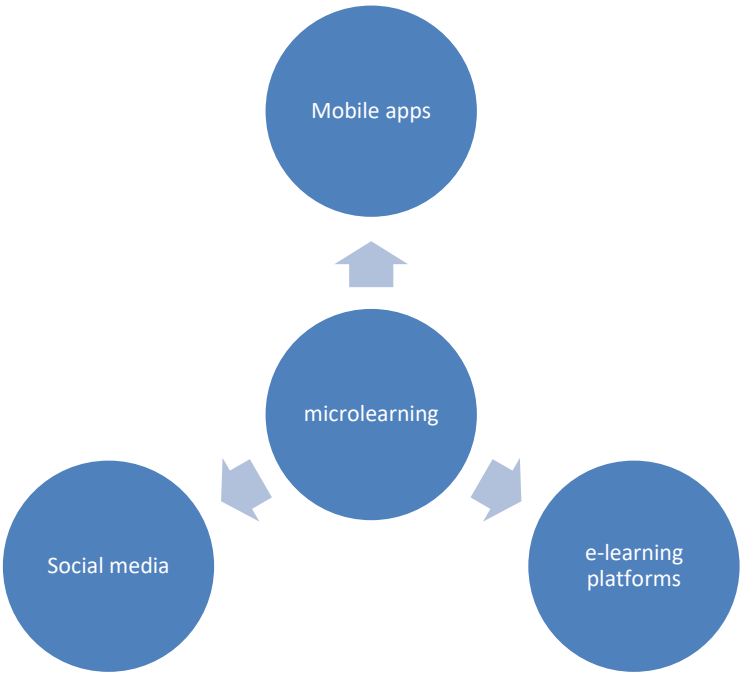

Figure 1. Some technological platforms for microlearning.

Every branch divided even further into smaller sections that will highlight what they have under each category. For example, under mobile apps, we would include apps like Duolingo and Quizlet. The e-learning platforms branch could showcase platforms like Coursera, Udemy, and LinkedIn Learning. The social media branch might cover platforms like YouTube, Instagram, and TikTok. Each platform would be represented on the diagram, and a few key figures would accompany it to show what the platform is contributing to the kind of education that microlearners are seeking. The aim of the whole project would be to demonstrate, visually and in words, the diversity of the tools available to learners who want quick education that can be done in the spaces of time between doing other things [14-17].

3. Cognitive Benefits and Effectiveness.

Information retention is one of the best-studied aspects of microlearning. Cognitive load theory (CLT), developed by John Sweller, provides a critical lens through which to understand this benefit (Table 1). According to CLT, the human brain has a limited capacity for processing new information in working memory, and this capacity can become overloaded when learners are exposed to too much information at once. This overload can result in poorer retention, as learners are unable to fully process, store, and retrieve information [18]. Microlearning

diminishes the intrinsic cognitive load, which refers to the complexity of the material itself, and the extraneous cognitive load, which originates from how the material is delivered. It does this by serving up learning content in small, easily digestible pieces and by presenting that content in an engaging manner. It turns out that doing these things makes microlearning a pretty good way to promote knowledge retention. [1, 6]. For example, studies suggested that learners who were exposed to microlearning modules retained up to 20% more information than did learners who were exposed to more traditional (that is, less engaging) formats. Moreover, Microlearning provided brief, yet adequate, learning events that ensured the learners had enough time to commit what they were learning to long-term memory. Immediate consolidation before the introduction of new material was key. Further, microlearning was often "multimedia" learning. Learners may have learned through video, audio, or even serious games. This was important because encoding and retrieval of information is best in a situation rife with varied stimuli. These varied, yet controlled, stimuli helped the brain create the kinds of pathways—cognitive, synaptic, and neural—that are necessary for the learning that we can see and measure [19, 20].

3.1.Spaced repetition and microlearning's enhancement of understanding.

imple memorization could not suffice and required a more profound cognitive engagement with the understanding of the material. This engagement was where spaced repetition—a core principle of microlearning—played a significant role. The act of revisiting learned material at spaced intervals over time was a prime practice for ensuring that the learned material wasn't easily forgotten but instead firmly embedded in the brain. On the most basic level, spaced repetition was counteracting the effects of the Ebbinghaus forgetting curve, which showed how our memory retention declined over time if we didn't attempt to review or reinforce what we had learned. Indeed, some of the deficits in learning and understanding could be traced to not using spaced repetition when we first learned something [21, 22].

Microlearning naturally supports spaced repetition by offering learners short, revisitable modules that they can access on-demand. Previous studies showed that the medical students using the spaced repetition condition recalled key terms and definitions with 16% to 25% greater accuracy than did students using the non-repetitive condition, who "crammed" the items just before an exam. In terms of deeper learning, the benefit of using spaced repetition with microlearning is that (a) when you encounter previously learned material, it has a better chance of being anchored in your long-term memory, and (b) you also have a better chance of understanding the material at a deeper level, such that you can apply it to novel situations. Flashcard-based apps and little, low-stakes quizzes were effective in using spaced repetition. These microlearning tools delivered information at well-timed intervals, allowing learners to really understand and remember what they had learned. Because the amount of information delivered at one time was not large, and because the timing of the delivery was not rushed, the brain did not feel overloaded, as it does during cramming sessions [23, 24].

3.2.Application of knowledge: transferring learning into real-world contexts.

One of the key indicators of effective learning is the ability to apply knowledge in real-world contexts. Microlearning has proven to be highly effective in this regard, largely because it breaks down complex tasks into smaller, actionable steps, making it easier for learners to translate theoretical knowledge into practical skills. Cognitive load theory again plays an

important role in understanding how microlearning supports the application of knowledge. The modular structure of microlearning allows learners to focus on mastering one specific skill or piece of knowledge at a time before moving on to the next. This step-by-step approach reduces the cognitive burden and ensures that learners fully grasp each component before combining them to perform more complex tasks [25, 26].

Research has shown that this incremental approach to learning leads to higher levels of knowledge transfer. Previous studies demonstrated that learners who used microlearning to practice problem-solving skills were more successful in applying those skills in real-world scenarios than those who learned through traditional, lecture-based methods. The reason for this is that microlearning encourages active learning by incorporating quizzes, simulations, and real-time feedback, all of which allow learners to practice and apply their knowledge in a controlled environment before moving into more unpredictable, real-world situations. Furthermore, microlearning's compatibility with spaced repetition enhances the ability to apply knowledge. As learners revisit content over time, they reinforce their understanding and become more confident in their ability to apply that knowledge in different contexts. This is particularly beneficial in fields such as medicine, engineering, and business, where learners must not only memorize theoretical concepts but also be able to apply them in practical, high-stakes situations. Microlearning also offers the advantage of flexibility, allowing learners to access just-in-time learning resources that can be immediately applied to solve real-world problems. For example, a mechanic might consult a microlearning module on a specific repair procedure right before beginning a job, ensuring that the information is fresh and immediately applicable. This form of microlearning is often referred to as performance support, and it has been shown to improve both the speed and accuracy with which learners can apply new knowledge [2, 6, 27].

Table 1. Cognitive Benefits and effectiveness of Microlearning.

Aspect	Description	References
Retention Improvement	Microlearning enhances retention by presenting information in smaller, manageable units, reducing cognitive overload. Learners retain up to 20% more information compared to traditional formats.	[1, 6, 18, 19]
Cognitive Load Theory	Cognitive Load Theory explains that the brain has limited processing capacity; microlearning mitigates this by delivering bite-sized content, reducing both intrinsic and extraneous cognitive loads.	[1, 6, 18]
Spaced Repetition	Microlearning supports spaced repetition, allowing learners to revisit material at increasing intervals, which strengthens neural pathways and improves understanding.	[21, 22, 23]
Application of Knowledge	Microlearning breaks down complex tasks into smaller steps, aiding the transfer of theoretical knowledge into practical skills, especially in high-stakes fields like medicine and engineering.	[25, 26, 27]
Active Learning	Incorporates interactive elements like quizzes and simulations that encourage active learning, enabling learners to practice skills in a controlled environment before applying them in real-world scenarios.	[2, 6, 27]

4. Challenges and Limitations of Microlearning

While microlearning has garnered attention for its effectiveness in enhancing knowledge retention and application, it is not without challenges and limitations. As a teaching method, it is well-suited to certain learning environments but may present drawbacks in others. This section explores key challenges associated with microlearning, including its suitability for complex topics, learner engagement, potential cognitive overload, and technological dependency.

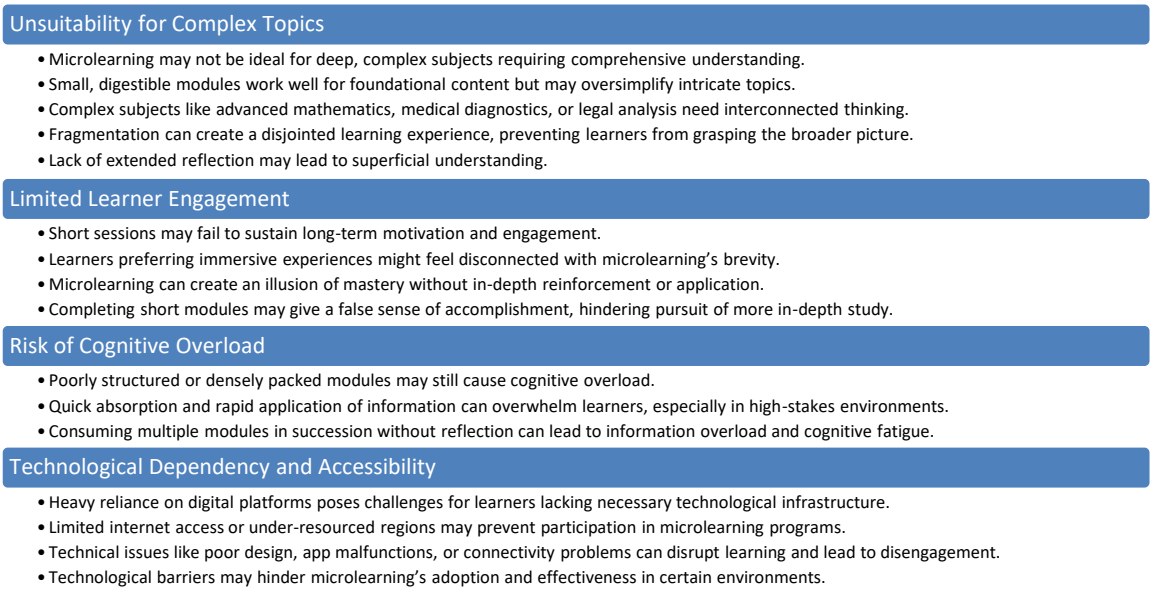

Figure 2. Challenges and limitations of microlearning.

4.1.Unsuitability for complex topics.

One of the primary limitations of microlearning is its potential inadequacy for deep, complex subjects that require comprehensive understanding. Microlearning focuses on delivering small, digestible chunks of information, which works well for straightforward or foundational content. However, topics that demand deep cognitive engagement, critical thinking, or interwoven concepts may not be effectively broken down into short learning segments. For example, complex subjects like advanced mathematics, medical diagnostics, or legal analysis require detailed explanations and interconnected thinking, which can be challenging to convey in small modules. The fragmentation of content in microlearning can lead to a disjointed learning experience, where learners fail to see the broader picture or how various concepts interrelate. Without the opportunity for extended reflection or synthesis, microlearning might oversimplify content, leading to superficial understanding. This limitation poses a challenge for educators who seek to use microlearning in subjects that require a more holistic, in-depth learning approach [1, 28].

4.2. Limited learner engagement.

Engaging learners over the long term can be difficult with microlearning. While its brevity can be an advantage for learners with short attention spans or limited time, the constant exposure to short, isolated learning sessions may not sustain motivation. Learners who prefer more immersive experiences might feel disconnected or disengaged when learning in microbursts. They may miss the richer interactions, discussions, or deeper analysis that longer learning formats typically provide. Furthermore, microlearning can create an illusion of learning completion without full mastery of a topic. The satisfaction of completing short modules can lead to learners believing they have mastered a subject without spending sufficient time on reinforcement or real-world application. This false sense of accomplishment might hinder learners from pursuing more in-depth study or practice, which is necessary to truly master a skill or concept [6, 12].

4.3.Risk of cognitive overload.

While microlearning is designed to reduce cognitive overload by presenting smaller amounts of information at a time, it may inadvertently cause cognitive overload in certain scenarios. If the learning material is not carefully structured or is too densely packed with complex information, learners may still experience cognitive strain. The expectation that learners can quickly absorb and apply knowledge in rapid succession could lead to overwhelmed individuals, especially when microlearning is used in high-stakes, fast-paced environments. Additionally, when multiple microlearning modules are consumed in quick succession, learners may experience information overload, especially if there is no time allocated for reflection or consolidation. While each microlearning session is short, the accumulation of these modules can result in cognitive fatigue, diminishing the overall effectiveness of the approach [29, 30].

4.4.Technological dependency and accessibility

Microlearning heavily relies on digital platforms, such as learning management systems (LMS), mobile apps, and multimedia content delivery. This reliance poses a challenge in terms of accessibility for learners who may lack the necessary technological infrastructure. Learners in under-resourced regions or those without reliable internet access may find it difficult to participate in microlearning programs, potentially creating a gap between learners who have access to technology and those who do not. Additionally, technical issues such as poor user interface design, app malfunctions, or connectivity problems can disrupt the learning experience, leading to frustration and disengagement. In environments where technology is not seamlessly integrated, microlearning may face significant obstacles in its adoption and effectiveness [1, 31, 32].

5. Conclusion

Microlearning represents a highly adaptable and flexible approach to modern education, particularly suited to the fast-paced, digital environment of contemporary learners. Its core strengths lie in delivering small, focused chunks of information that can enhance knowledge retention and reduce cognitive load, allowing learners to engage with content at their own pace. This makes microlearning an effective tool for reinforcing foundational knowledge and skills, especially when integrated with digital platforms like mobile apps and e-learning systems. However, while microlearning has proven beneficial in improving learning outcomes, it is not without limitations. Its reliance on brevity may lead to shallow learning, particularly in complex subjects that require deeper cognitive engagement and critical thinking. As such, while microlearning excels in providing accessibility and flexibility, it should be used in conjunction with more traditional, in-depth learning methods to ensure a comprehensive understanding of complex concepts. By balancing these approaches, educators can leverage the strengths of microlearning while mitigating its challenges, leading to more effective and holistic education outcomes.

Acknowledgments

The author wishes to thank State University of Zanzibar Tanzania. The author also wishes to thank Universidad Central del Ecuador Ecuador and Universidad de Antioquia Colombia for the support provided in completing the reflection.

Competing Interest

All authors declare no competing interest.

Author Contribution

Ahmed Mostrady: Writing, Conceptualization, Methodology; Eva Sanchez-Lopez: Writing, Conceptualization, Methodology; Andres Filipe Gonzalez-Sanchez: Writing, Data Collection, Data Analysis.

Reference

[1] Betancur-Chicué, V.; García-Valcárcel Muñoz-Repiso, A. (2023). Microlearning for the Development of Teachers' Digital Competence Related to Feedback and Decision Making. *Education Sciences*, *13*, 722. https://doi.org/10.3390/educsci13070722.

[2] Ester, P.; Morales, I.; Herrero, L. (2023). Micro-Videos as a Learning Tool for Professional Practice during the Post-COVID Era: An Educational Experience. *Sustainability*, *15*, 5596. https://doi.org/10.3390/su15065596.

[3] Sirwan Mohammed, G.; Wakil, K.; Nawroly, S. (2018). The Effectiveness of Microlearning to Improve Students' Learning Ability. *International Journal of Educational Research Review*, *3*, 32–38. https://doi.org/10.24331/ijere.415824.

[4] Sun, G.; Cui, T.; Beydoun, G.; Chen, S.; Dong, F.; Xu, D.; Shen, J. (2017). Towards Massive Data and Sparse Data in Adaptive Micro Open Educational Resource Recommendation: A Study on Semantic Knowledge Base Construction and Cold Start Problem. *Sustainability*, *9*, 898. https://doi.org/10.3390/su9060898.

[5] Nur Fitria, T. (2022). Microlearning in Teaching and Learning Process: A Review. *CENDEKIA: Jurnal Ilmu Sosial, Bahasa dan Pendidikan*, *2*, 114–135. https://doi.org/10.55606/cendikia.v2i4.473.

[6] Skalka, J.; Drlik, M. (2020). Automated Assessment and Microlearning Units as Predictors of At-Risk Students and Students' Outcomes in the Introductory Programming Courses. *Applied Sciences*, *10*, 4566. https://doi.org/10.3390/app10134566.

[7] Naveed, Q.N.; Choudhary, H.; Ahmad, N.; Alqahtani, J.; Qahmash, A.I. (2023). Mobile Learning in Higher Education: A Systematic Literature Review. *Sustainability*, *15*, 13566. https://doi.org/10.3390/su151813566.

[8] Dimulescu, C. (2023). E-Learning Platform Usage and Acceptance of Technology after the COVID-19 Pandemic: The Case of Transilvania University. *Sustainability*, *15*, 16120. https://doi.org/10.3390/su152216120.

[9] Criollo-C, S.; Guerrero-Arias, A.; Jaramillo-Alcázar, Á.; Luján-Mora, S. (2021). Mobile Learning Technologies for Education: Benefits and Pending Issues. *Applied Sciences*, *11*, 4111. https://doi.org/10.3390/app11094111.

[10] Song, C.; Shin, S.-Y.; Shin, K.-S. (2023). Optimizing Foreign Language Learning in Virtual Reality: A Comprehensive Theoretical Framework Based on Constructivism and Cognitive Load Theory (VR-CCL). *Applied Sciences*, *13*, 12557. https://doi.org/10.3390/app132312557.

[11] Popovych, V.; Drlik, M. (2024). Identification of Students with Similar Performances in Micro-Learning Programming Courses with Automatically Evaluated Student Assignments. *Applied Sciences*, *14*, 3615. https://doi.org/10.3390/app14093615.

[12] Bitakou, E.; Ntaliani, M.; Demestichas, K.; Costopoulou, C. (2023). Assessing Massive Open Online Courses for Developing Digital Competences among Higher Education Teachers. *Education Sciences*, *13*, 900. https://doi.org/10.3390/educsci13090900.
[13] LinkedIn Learning Comprehensive Review. (2 May 2024) Available online: https://octopuscrm.io/blog/linkedin-learning-review/.
[14] Perifanou, M.; Tzafilkou, K.; Economides, A.A. (2021). The Role of Instagram, Facebook, and YouTube Frequency of Use in University Students' Digital Skills Components. *Education Sciences*, *11*, 766. https://doi.org/10.3390/educsci11120766.
[15] Abbas, J.; Aman, J.; Nurunnabi, M.; Bano, S. (2019). The Impact of Social Media on Learning Behavior for Sustainable Education: Evidence of Students from Selected Universities in Pakistan. *Sustainability*, *11*, 1683. https://doi.org/10.3390/su11061683.
[16] Swanepoel, J.A. (2024). Cohesive Online Education Model Using Emergent Technologies to Improve Accessibility and Impact. *Education Sciences*, *14*, 522. https://doi.org/10.3390/educsci14050522.
[17] Dahri, N.A.; Al-Rahmi, W.M.; Almogren, A.S.; Yahaya, N.; Vighio, M.S.; Al-Maatuok, Q. (2023). Mobile-Based Training and Certification Framework for Teachers' Professional Development. *Sustainability*, *15*, 5839. https://doi.org/10.3390/su15075839.
[18] Venkat, M.V.; O'Sullivan, P.S.; Young, J.Q.; Sewell, J.L. (2020). Using Cognitive Load Theory to Improve Teaching in the Clinical Workplace. *MedEdPORTAL*, *16*, 10983. https://doi.org/10.15766/mep_2374-8265.10983.
[19] Alias, N.; Razak, R. (2023). Exploring the Pedagogical Aspects of Microlearning in Educational Settings: A Systematic Literature Review. *Malaysian Journal of Learning and Instruction*, *20*. https://doi.org/10.32890/mjli2023.20.2.3.
[20] Balasundaram, S.; Mathew, J.; Nair, S. (2024). Microlearning and Learning Performance in Higher Education: A Post-Test Control Group Study. *Journal of Learning for Development*, *11*(1), 1–14. https://doi.org/10.32890/jld2024.11.1.1.
[21] Ebbinghaus's Forgetting Curve. (accessed on 2 May 2024) Available online: https://www.mindtools.com/a9wjrjw/ebbinghauss-forgetting-curve.
[22] Wollstein, Y.; Jabbour, N. (2022). Spaced Effect Learning and Blunting the Forgetfulness Curve. *Ear, Nose & Throat Journal*, *101*(9_suppl), 42S–46S. https://doi.org/10.1177/01455613231163726.
[23] Pashler, H.; Rohrer, D.; Cepeda, N.J.; et al. (2007). Enhancing learning and retarding forgetting: Choices and consequences. *Psychonomic Bulletin & Review*, *14*, 187–193. https://doi.org/10.3758/BF03194050.
[24] Kang, S.H.K. (2016). Spaced Repetition Promotes Efficient and Effective Learning: Policy Implications for Instruction. *Policy Insights from the Behavioral and Brain Sciences*, *3*(1), 12–19. https://doi.org/10.1177/2372732215624708.
[25] Partarakis, N.; Zabulis, X. (2024). Applying Cognitive Load Theory to eLearning of Crafts. *Multimodal Technologies and Interaction*, *8*, 2. https://doi.org/10.3390/mti8010002.
[26] Namestovski, Ž.; Kovari, A. (2022). Framework for Preparation of Engaging Online Educational Materials—A Cognitive Approach. *Applied Sciences*, *12*, 1745. https://doi.org/10.3390/app12031745.
[27] Fidan, M. (2023). The effects of microlearning-supported flipped classroom on pre-service teachers' learning performance, motivation and engagement. *Education and Information Technologies*, *28*, 1–28. https://doi.org/10.1007/s10639-023-11639-2.
[28] Skalka, J.; Drlik, M.; Benko, L.; Kapusta, J.; Rodríguez del Pino, J.C.; Smyrnova-Trybulska, E.; Stolinska, A.; Svec, P.; Turcinek, P. (2021). Conceptual Framework for Programming Skills Development Based on Microlearning and Automated Source Code Evaluation in Virtual Learning Environment. *Sustainability*, *13*, 3293. https://doi.org/10.3390/su13063293.

[29] Sozio, G.; Agostinho, S.; Tindall-Ford, S.; Paas, F. (2024). Enhancing Teaching Strategies through Cognitive Load Theory: Process vs. Product Worked Examples. *Education Sciences*, *14*, 813. https://doi.org/10.3390/educsci14080813.

[30] Crandall, R.; Karadoğan, E. (2021). Designing Pedagogically Effective Haptic Systems for Learning: A Review. *Applied Sciences*, *11*, 6245. https://doi.org/10.3390/app11146245.

[31] Gligorea, I.; Cioca, M.; Oancea, R.; Gorski, A.-T.; Gorski, H.; Tudorache, P. (2023). Adaptive Learning Using Artificial Intelligence in e-Learning: A Literature Review. *Education Sciences*, *13*, 1216. https://doi.org/10.3390/educsci13121216.

[32] Sivagurunathan, S.; Parthasarathy, S. (2022). A Framework for a Seamless Transformation to Online Education. *Computers*, *11*, 183. https://doi.org/10.3390/computers11120183.