



**MALAYSIAN JOURNAL OF LEARNING  
AND INSTRUCTION**

<https://e-journal.uum.edu.my/index.php/mjli>

How to cite this article:

Nurul Fitriah Alias & Rafiza Abdul Razak. (2023). Exploring the pedagogical aspects of microlearning in educational settings: A systematic literature review. *Malaysian Journal of Learning and Instruction*, 20(2), 267-294. <https://doi.org/10.32890/mjli2023.20.2.3>

**EXPLORING THE PEDAGOGICAL ASPECTS OF  
MICROLEARNING IN EDUCATIONAL SETTINGS:  
A SYSTEMATIC LITERATURE REVIEW**

**<sup>1</sup>Nurul Fitriah Alias & <sup>2</sup>Rafiza Abdul Razak**

Department of Curriculum and Instructional Technology,  
University of Malaya, Kuala Lumpur, Malaysia.

*<sup>2</sup>Corresponding author: rafiza@um.edu.my*

Received: 8/3/2023    Revised: 18/5/2023    Accepted: 30/5/2023    Published: 31/7/2023

**ABSTRACT**

**Purpose:** Technology has revolutionized education, leading to innovative learning techniques like microlearning. Microlearning is gaining popularity in higher education and corporate settings for its student-centred approach and well-planned modules. However, its pedagogical design is complex, requiring a systematic review of studies to identify effective practices. The purpose of this study is to conduct a systematic literature review to identify effective practices of microlearning in teaching and learning in higher education between 2014 and 2023. The study aims to analyse the pedagogical design of microlearning in educational settings.

**Methodology:** The study follows the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines. A systematic literature review was conducted to identify, evaluate,

interpret, and analyse available studies on the practices of microlearning. The analysis focused on the research question and identified themes related to the pedagogical design of microlearning.

**Findings:** The analysis revealed two final themes: the design of microlearning content and instructional flow. The design of microlearning content focused on developing microlearning material, while instructional flow focused on organizing content learning. These findings provide insights into effective practices for curriculum designers and instructors in designing and developing microlearning strategies in teaching and learning.

**Significance:** The findings of this study have significant implications for educators and curriculum designers. The study highlights the importance of considering both the design of microlearning content and instructional flow in creating engaging and effective microlearning experiences for students in higher education. By incorporating these findings, educators and curriculum designers can enhance the quality of microlearning strategies in teaching and learning.

**Keywords:** Microlearning, systematic literature review, teaching, pedagogical design, higher education.

## INTRODUCTION

Education requires changes in the context in which we live, work, and learn (Giurgiu, 2017). Recently, this has been demonstrated through the effects of social, economic, and technological changes on daily life that have led to the introduction of new concepts and learning strategies. Nowadays, people spend a significant amount of time on the internet for various reasons such as communicating, having fun, learning, and working (Salleh et al., 2022). Electronic devices have become more flexible and accessible with various software over time, resulting in a wide range of new learning methods and techniques. The emergence and evolution of technology have brought many changes in education, particularly the way teaching and learning is conducted, which has shaped the learning and knowledge attaining process. Hence, educational institutions are encouraged to employ various innovative learning techniques and approaches to motivate and engage students more effectively during the learning process.

The significance of microlearning in the context of higher education has grown in recent years. Research has shown that microlearning is gaining popularity, particularly since the start of COVID-19, and it has been proven to be an effective instructional strategy for mitigating the effects of COVID-19 (Sankaranarayanan et al., 2022). This teaching and learning strategy has gained popularity among academicians in higher education and in corporate settings due to its prominent features such as being student-centred and interactive and its capability of delivering well-planned modules and instruction (Jomah et al., 2016). Microlearning can be defined as the process of learning through small chunks of learning activities which are thoroughly designed to be concise and focused (Kadiev et al., 2021). Jahnke et al. (2020) asserted that microlearning can be described as learning in small chunks depicted by short bite-sized lessons. Hence, what is unique about this learning approach is that it provides shorter instruction units and learning activities that are compatible with the needs and demands of new millennium learners, otherwise known as digital natives.

Microlearning mainly refers to the use of micro-sized content for learning that focuses on small topics that can be learned in a short period of time. In addition, microlearning can be applied through various types of technologies such as mini lectures using videos, text, images, and audio. Other tools that can be used include podcasts, social media, infographics, gamification, and more (Shabadurai et al., 2022). The objective of using microlearning is to disseminate knowledge using short and focused units, cumulatively demonstrating concepts of a larger topic in smaller chunks to make it easier for learners to concentrate and retain new information (Fernandez, 2014). Microlearning is designed to overcome the limits of the human brain with respect to its attention span and avoid cognitive overload during the learning process (Alqurashi, 2017). What makes microlearning intriguing is that it provides learners with the ability to quickly access educational content and tasks, allowing them to gain knowledge and skills effectively and apply what they have learned in practical situations. (Sankaranarayanan et al., 2022).

This paper delves into the fundamental components required for the effective execution of microlearning as an instructional approach in higher education. The primary objective is to offer a thorough comprehension of microlearning and its ability to revolutionise

teaching and learning techniques. By exploring key aspects of microlearning, this paper aims to provide insights into how it can be implemented successfully in educational contexts, leading to improved learning outcomes.

## **LITERATURE REVIEW**

Researchers agree that the microlearning approach was first theorised by Theo Hug in 2005, who characterised microlearning based on seven dimensions. Hug (2005) highlighted that microlearning involves brief lessons that focus on a single objective, can be completed as needed, and can be delivered through a variety of media formats. Hug (2005) described microlearning as an instructional framework based on seven dimensions. These dimensions are (1) Learning Time which is short measurable time, effort and degree of time consumption, (2) Learning Content with small learning units, simple issues and narrow topics, (3) Curriculum that refers to the set of modules and type of learning modality such as informal learning, (4) Learning Form which focuses on fragments, episodes and knowledge nuggets, (5) Learning Process that focuses on separate, connected, situated or integrated activities, (6) Learning Medium which employs learning objects, face-to-face, and multimedia, and (7) Learning Type that entails behaviourist, cognitivist, constructivist, and social learning perspectives. However, while these seven dimensions are crucial as part of the design aspects of microlearning, they lack the pedagogical aspect which includes the key elements to an effective microlearning design, especially if it is to be implemented in traditional face-to-face learning in the classroom. It is important to note that the compact size of microlearning does not equate to a simple educational approach. In fact, designing microlearning is more challenging as it involves combining multiple teaching methods (Kerres, 2007). Therefore, this current study seeks to explore pedagogical practices of microlearning so that educators will be able to employ microlearning practices in their teaching. The resultant findings will also assist educators to design and develop microlearning tools and activities.

Since Hug's (2005) presentation of the seven-dimensional framework, numerous academics have contributed a great deal of theoretical and empirical work to the body of knowledge in expanding the notion of microlearning. For instance, Kovachev et al. (2011) expanded Hug's concept to include technology and defined microlearning as a

technology-enhanced learning style that makes use of brief, targeted learning units that may be absorbed and learned quickly. Buchem and Hamelman (2010) broadened the definition of microlearning by tying it to several concepts, including (1) microcontent: which refers to information presented in a concise format, (2) Web 2.0: where microlearning takes place in an open and fragmented digital environment, (3) Social software that is characterised by its ability to facilitate social interaction among learners with varying backgrounds, interests, and learning goals, (4) e-learning 2.0, where microlearning can also occur within a structured e-learning setting, (5) Personal learning environment, which allows learners to have individualised access to an ongoing learning experience, (6) Informal learning, where microlearning occurs beyond formal structures in digital, micromedia environments (Lindner, 2006), and (7) Work-based learning, whereby microlearning is also related to work-based learning where microtraining can refer to short work-based training formats (Buchem & Hamelman, 2010). Microtraining is beneficial to support informal learning in the workplace as it offers flexible learning and requires less time and resources.

Buchem and Hamelman (2010) also concluded that the design of microlearning content is based on five key principles including (1) format: microcontent must be presented in small formats for quick perception by learners, (2) focus: microcontent should concentrate on a specific topic or idea, (3) autonomy: microcontent must be self-contained and understandable without additional external information, (4) structure: microcontent must be organised with components such as title, topic, author, date, tag, and URL, and (5) addressability: microcontent must be created as a single accessible internet resource through a permalink or URL. The authors emphasised that the main goal of microlearning design is not just to organise lessons hierarchically, but more importantly to engage learners as active participants in the learning process. Hence, another aspect to be considered when designing microlearning is to include strategies that encourage learner participation.

However, the lack of comprehensive studies on the pedagogical aspect of microlearning has led Leong et al. (2021) to urge future researchers to focus on cross-disciplinary studies aimed at building a more comprehensive theoretical framework to better understand the effective use of microlearning in supporting learning and higher education in practice. In addition, Alqurashi (2017) also concurred

that research investigating the integration of technology to create microlearning especially in the context of higher education is still in its infancy. Hence, this current study sought to explore the pedagogical aspects of microlearning for it to be effectively implemented in higher education teaching and learning. Wang et al. (2021) believed that microlearning holds great potential, not only in assisting institutions to stay afloat, but that it could also be instrumental in bringing about a change in teaching and learning experiences. Therefore, the purpose of this systematic review paper was to investigate the pedagogical design of microlearning so that it can be integrated in teaching and learning.

The purpose of this systematic literature review (SLR) article is to provide a comprehensive overview of research on microlearning during the last ten years (from 2014 to 2023) to highlight key aspects that are necessary for its successful implementation in teaching and learning. The methodology followed the preferred reporting items for systematic reviews and meta-analysis (PRISMA) guidelines outlined by Moher et al. (2009) to ensure transparent and thorough reporting. This review is intended for researchers who are interested in gaining a deeper understanding of microlearning as an innovative teaching method; policymakers such as government and education curriculum centres who manage designing and reviewing curriculum and lastly, educators as the findings will be able to assist them in designing lessons with the integration of microlearning to maximise students' learning process that will lead to more effective and successful learning.

## **THEORETICAL FOUNDATION OF MICROLEARNING**

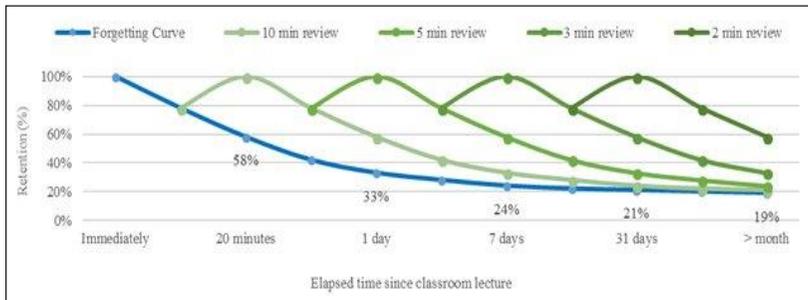
Microlearning is a modern approach to learning that focuses on delivering bite-sized, easily digestible pieces of information to learners. The theory behind microlearning is that learners are better able to retain information when it is presented to them in small chunks, as opposed to large amounts of information that can be overwhelming and difficult to retain. This section will examine the theoretical foundation of microlearning, including the cognitive and educational theories that have influenced its development.

The cognitive theory is one of the most influential theories behind microlearning, where an important theory behind microlearning is the "forgetting curve" (Ebbinghaus, 1885). This theory states that people

tend to forget information over time, and that the rate of forgetting is greatest in the first few days after the information is consumed. Microlearning addresses this issue by delivering information in small doses over time, which ensures that learners have constant exposure to the information and reduces the rate of forgetting. In addition, the theory states that the human brain has limited capacity to process and retain information, and that it is more effective to present information in small, manageable chunks. This is known as the “spacing effect” (Ebbinghaus, 1885), where information is more easily retained when it is spaced out over time, rather than presented all at once. Microlearning takes advantage of this principle by breaking down information into smaller, manageable pieces that can be delivered over time, allowing learners to better retain and recall information. Figure 1 as follows illustrates the forgetting curve and ways of overcoming it through revision using microlearning.

**Figure 1**

*Overcoming the Ebbinghaus forgetting curve (Ebbinghaus, 1885)*



Microlearning is a pedagogical approach that involves delivering learning content in small, manageable units, often in the form of short, focused lessons or activities. This approach has gained popularity in recent years due to the increasing demands on learners’ time and attention, the rise of mobile devices and the availability of online learning resources.

One study by Polasek and Javorcik (2019) investigated the application of microlearning in teaching computer architecture and operating system basics. The study involved a group of 26 first-year students who were randomly assigned to either a traditional lecture-based class or a microlearning class. The results of the study showed that students in the microlearning class performed better in the final exam than

those in the traditional lecture-based class. The microlearning class also had higher student engagement and satisfaction levels, as well as lower levels of stress and anxiety. The researchers concluded that microlearning can be an effective teaching approach and that it has the potential to enhance student learning outcomes and engagement. Another study by Han (2019) discussed the use of micro-lecture teaching in improving the learning outcomes of non-English majors at the North China Electric Power University, which is a method of delivering short, concise lectures designed to be easily understandable and memorable. The author conducted a study with 70 non-English major students and found that micro-lecture teaching had a significant positive effect on their listening and speaking skills in English. The study suggested that micro-lecture teaching can be a useful tool for educators looking to improve students' learning outcomes. Zarshenas et al. (2022) investigated the effect of micro-learning on the learning and self-efficacy of nursing students. The researchers conducted an interventional study involving 64 nursing students who were randomly assigned to either a micro-learning group or a traditional learning group. The micro-learning group received short and focused learning modules on specific topics related to nursing, while the traditional learning group received conventional classroom-based instruction. The researchers measured the participants' learning outcomes and self-efficacy levels before and after the intervention. The results showed that the micro-learning group had significantly higher learning outcomes and self-efficacy levels than the traditional learning group. The microlearning group also reported higher levels of engagement and motivation compared to the traditional learning group. The researchers concluded that micro-learning can be an effective teaching method for students and can improve their learning outcomes and self-efficacy. A previous study by Kasuma et al. (2021) revealed that self-efficacy was found to be a key factor in students' success in learning, especially among students with higher levels of self-efficacy who became more engaged and motivated. The study suggested that incorporating microlearning into education could lead to more efficient and effective learning experiences for students.

The findings reviewed here suggest that microlearning can be an effective method for enhancing knowledge retention, particularly in corporate training, higher education, and professional development contexts. This is likely due to its ability to deliver learning content in small, manageable units that are easy to understand and retain, along with other added benefits such as its flexibility and convenience. However, more research is needed to determine the optimal design

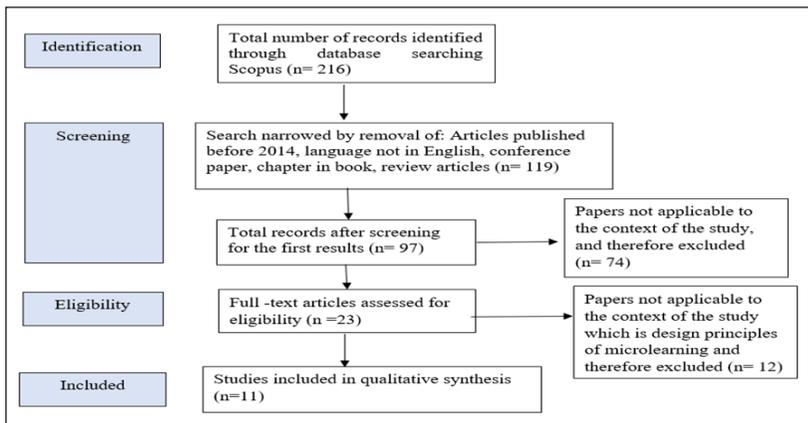
and implementation of microlearning pedagogy, and to understand how it may vary in terms of context and learner population.

## METHODOLOGY

The Systematic Literature Review (SLR) is a method to identify, assess, interpret, and analyse existing research findings related to a specific topic, research question, or phenomenon. The objective of this study is to conduct an SLR to summarise the literature on the use of microlearning in higher education teaching and learning. The review was conducted according to the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Moher et al., 2009), which consists of four steps: identification, screening, eligibility, and inclusion criteria. The identification step involves finding relevant articles using keywords and database searches. The screening step involves selecting articles based on predetermined criteria, and the eligibility step involves evaluating articles to ensure they meet the inclusion criteria. The final step is the inclusion criteria, where the remaining articles are analysed. There are several benefits of using PRISMA as a guide for conducting an SLR, as its searching procedures are systematic, it provides a clear understanding of the process, and it makes the evaluation of sources of information easier (Mohamed et al., 2020). The following Figure 2 illustrates the process of conducting the SLR in this study.

**Figure 2**

### *Research Data Search & Selection Flow*



## Identification

The initial step in conducting the SLR using PRISMA is the identification process, where the main keywords are expanded by identifying and listing synonyms to retrieve as many articles from the database as possible. The researcher used the Scopus database at Universiti Malaya to generate search strings using the keyword “microlearning”. The search strings were then entered in the Advanced menu’s Enter query string. This allowed for documents to be retrieved in the first phase.

## Screening

The second stage is the screening process, where articles obtained from the database are selected or discarded based on criteria established by the researcher. Articles that meet the criteria are referred to as “included articles”, while those that do not meet the criteria are removed and are referred to as “excluded articles.” The search was carried out in Scopus using the keyword “microlearning” from 2014 to 2023, with a restriction on studies written in English. The inclusion and exclusion criteria are summarised in Table 1.

**Table 1**

### *Inclusion and Exclusion Criteria*

Criteria	Inclusion	Exclusion
Types of articles	Journals (research articles)	Conference papers, chapters in books, review articles
Language	English	Non-English
Timeline	From 2014 until 2023	Published before 2014

The researcher continued the process by selecting “article” as the type of document in the database and limiting the search to those in the English language. This was accomplished by clicking on the left side box of the website interface and selecting the “Limit to” button at the bottom of the check boxes. This resulted in 97 articles being produced from the screening process. The researcher then analysed the distribution of the articles, considering the year of publication, subject area, authors, countries, and authors affiliated with universities. Out of the 97 articles, 74 were excluded for reasons such as being irrelevant

to the study context, lack of access to the full text, and insufficient information in the abstracts regarding the results and a comprehensive understanding of the topic.

### **Eligibility**

The next step in the SLR process was the eligibility phase, where 23 articles were chosen. The articles were thoroughly assessed by reading through the titles, abstracts, methods, results, and discussions to make sure they satisfied the inclusion criteria and were aligned with the current research goals. The selection of articles to be reviewed was carried out in three stages. The first stage involved screening the titles and abstracts, the second stage involved analysing the articles based on established selection criteria and organising the results into a table, and the third stage involved reading and synthesising all results into one document. The researcher only included articles that were relevant to the research questions and excluded those that did not examine microlearning practices. After eliminating articles that were not applicable to the study of microlearning design principles, 11 articles remained and were deemed suitable for analysis. Table 1 summarises the review of research on microlearning pedagogical design principles.

## **RESULTS**

The research resulted in 217 hits, however, only 11 studies satisfied the inclusion criteria and were analysed. Table 2 shows the themes of the 11 studies. The studies included in the review were conducted in Malaysia (2), United Kingdom (1), USA (1), Norway (1), Germany (1), Australia (1), Korea (1), Thailand (1), the Netherlands (1), and Turkey (1). They were published between 2014 and 2023, with the majority being published in 2020. The sample sizes of the studies varied and the data was mainly collected through interviews and surveys. The systematic review uncovered two central themes related to the design of microlearning, with a focus on the design of the microlearning content and instructional flow of microlearning (as shown in Table 2).

**Table 2**  
*Review of Research on the Pedagogical Design of Microlearning*

Author & Year	Country	Respondent	Education discipline	Theme 1: Design of microlearning content				Theme 2: Instructional flow of microlearning		
				Offers small/single chunks and single topics, easy to understand	Arranged in short-time spans	Relevant topics	Interactive micro content	Describes the learning objective of the lesson	Using different and attractive media formats	Encourages interaction with peers
Ten Cate, D., Dikken, J., Eitema, R., Schoonhoven, L., Schuurmans, M. J. (2023)	The Netherlands	Older adults, nurses, nursing assistants, experts, and other professionals involved in nutritional care	Medical education	✓	✓	✓	✓	✓	✓	✓
Thillainadesan, J., Le Couteur, D.G., Haq, I., Wilkinson, T.J. (2022)	Australia	-	Medical education	✓	✓	✓	✓	✓	✓	✓
Slabadurai, Y., Chua, F.-F., Lim, T.Y. (2022)	Malaysia	150 employees from a private university who had completed at least one online training	Education technology	✓	✓	✓	✓	✓	✓	✓
McKee, C., Ntokos, K. (2022)	United Kingdom (UK)	94 students	Education	✓	✓	✓	✓	✓	✓	✓

(continued)

Author & Year	Country	Respondent	Education discipline	Theme 1: Design of microlearning content			Theme 2: Instructional flow of microlearning			
				Offers small/single chunks and single topics, easy to understand	Arranged in short-time spans	Relevant topics	Interactive micro content	Describes the learning objective of the lesson	Using different and attractive media formats	Encourages interaction with peers
Choo, C.Y., Abdul Rahim, A.S. (2021)	Malaysia	116 students enrolled as first semester students in Bachelor of Pharmacy course	Education	✓	✓	✓	✓	✓	✓	✓
Beste, T. (2021)	Norway	334 employees of a Norwegian public sector company.	Organisational learning	✓	✓	✓	✓	✓	✓	✓
Jahnke, I., Lee, Y.M., Pham, M., He, H., Austin, L. (2020)	United States	-	Industry	✓	✓	✓	✓	✓	✓	✓
Chai-Arayalert, S., Puttinaovaratt, S. (2020)	Thailand	Students pursuing mangrove ecology education (number of students—not specified)	Environmental education	✓	✓	✓	✓	✓	✓	✓
Hesse, A., Ospina, P., Wieland, M., Yepes, L., Nguyen, B., Heuwer, W. (2019)	Germany	243 farm owners, employees, and veterinarians	Industry (dairy farms)	✓	✓	✓	✓	✓	✓	✓
Park, Y., Kim, Y. (2018)	Korea	Experts working in related areas	Education	✓	✓	✓	✓	✓	✓	✓
Alqurashi, E. (2017)	Turkey	-	Education	✓	✓	✓	✓	✓	✓	✓

## **Design of the Microlearning Content**

The literature for content design and development mainly focused on characteristics for developing microlearning content. This involved adhering to the fundamental design principles of the microlearning content like small bite-sized and focused content. To construct the course content, the SLR found that it was crucial to keep didactic design principles in mind when creating any learning materials. Shabudurai et al. (2022) investigated the design of micro-sized content for online training of employees from a private university. Based on the survey and focus group interview, they found that the video element was recognised to be the most popular element of microlearning, followed by static text and infographics. The least popular element was the podcast. This indicated that only static text and video were widely used as they could easily be taken from any website. Besides that, the study also identified the ideal length of micro-sized content for microlearning, which was between 5–7 minutes in length, followed by 7–10 minutes and 3–5 minutes. The participants involved in the study showed the least interest in shorter content, which was on average anything less than three minutes, according to the data. The participants in the study also regarded that “short duration” was the most advantageous characteristic of microlearning, followed by other characteristics namely focused, independent, interactive, and responsive. In addition, Choo and Abdul Rahim (2021) explored pharmacy students’ perceptions and performance in microlearning. They utilized a microlearning approach by breaking down topics into smaller chunks and assessing learning performance with online quizzes via Google Forms. This was in line with the focused characteristic of microlearning, where information is delivered through bite-sized learning content that can be tailored to be quick, convenient, and topic-centred for learners (Thillainadesan et al., 2022).

Chai-Arayalert and Puttinaovarat (2020) found that the outcomes of microlearning were better when students were not forced to study for long stretches of time, mainly due to their limited attention span. They found that extensive content may cause learners to get bored and fail to fully comprehend the content. This finding suggested that from the content design perspective, microlearning is beneficial mainly for its efficiency in retrieving content quickly, in addition to its practicality and diversity in facilitating on-demand content acquisition.

Jahnke et al. (2020) conducted a study to develop design principles for mobile microlearning. The study took place in 2017 and 2018 and was divided into two phases. In the first phase, the researchers conducted a literature review of current microlearning strategies, specifically focusing on mobile platforms, through two rounds of iterations. In the second phase, semi-standardised interviews were conducted with industry experts selected through purposeful sampling. These experts were selected based on their level of expertise and recognition as leaders in the field of mobile microlearning and included directors, founders, and pioneers with over 15 years of experience in microlearning systems and start-ups. The data collected from the literature review, industry reports, and interviews were analysed to create the underlying design principles of mobile microlearning. Mobile microlearning entailed the use of mobile technologies to deliver learning, and the term “mobile” was first introduced in 2012 to emphasise that the educational material was designed for smartphones. This appeals to learners who are not in the traditional office or classroom environment as they can access the learning resources at their preferred time and place due to the asynchronous nature of microlearning. The concept of mobile microlearning has gained popularity in recent years, as evidenced by the development of numerous mobile microlearning platforms. Some of these platforms include Codecademy, EdX, Khan Academy, Udacity, and Udemy (Jahnke et al., 2020).

Despite the increasing popularity and attention towards mobile microlearning, the underlying fundamental principles to design and develop mobile microlearning platforms is still limited as this aspect has not received enough attention and has not been sufficiently investigated (Cairness, 2017, as cited in Jahnke et al., 2020). While this current study does not focus on developing design principles for mobile microlearning, the findings from the study conducted by Jahnke et al. (2020) was deemed helpful for the researcher to explore pedagogical designs of the microlearning approach for teaching and learning. The study was conducted through a thorough examination of academic literature, industry reports, and interviews with industrial professionals, and subsequently, derived eight design principles for a mobile microlearning platform. The first design principle emphasises interactive micro-content, which engages learners through interactive elements such as simulations, drag-and-drop activities, and quizzes that allow them to apply what they have learned. The curriculum should also encourage learners to apply problem-solving skills rather

than just watching videos. The second design principle highlights the importance of chunked courses, which are short in duration (30 to 90 seconds) and focuses on a single learning aim, topic, concept, or idea. This approach aligns with the activity-based model of instruction, where students learn through their own activities rather than just following the teacher's guidance.

The third design principle relates to the instructional flow of the activity-based model of instruction, which emphasises on structured lessons in a sequenced form with a wide range of media formats and immediate feedback for learners. The fourth design principle stresses on the need for system design in mobile apps, which should be available on various operating systems, allows content to be downloaded for offline usage, provides push notifications, and tracks learners' progress. The fifth design principle emphasises the importance of focusing on learners' needs to ensure that they can acquire knowledge quickly and easily through the platform. The sixth design principle highlights the need for supportive social structures that encourages collaboration among learners and teachers' active involvement in the system. The seventh design principle emphasises that the platform should be affordable and reasonable for learners. The eighth design principle highlights that the curriculum should provide single lessons of microlearning that are embedded in a larger curriculum, and that an individual lesson could add up to a certificate or degree. Overall, these design principles provide a comprehensive framework for designing an effective mobile microlearning platform that aligns with the needs of learners, teachers, and industry professionals.

These eight design principles provide key strategies for the instructional design of the mobile microlearning lesson. However, a more critical eye on the design principles of microlearning is needed for it to be embedded in the higher education curriculum since the literature has indicated rather scarce investigations in this area. Hence, this current study sought to explore this area of concern.

Chai-Arayalert and Puttinaovarat (2020) developed a mobile microlearning application targeted at learners studying mangrove ecology. The study outlined several basic requirements for designing the self-learning application based on the micro-learning approach. The first principle involved creating microcontent, which needed to be created in the form of single content units that may be quickly

and easily understood and uses a variety of styles to grab learners' attention. The learning content provided in the application should be relevant, concise, appropriate and adequate to be delivered through a mobile device. The second principle required that the activity must be of a limited duration. This allows the learners to concentrate on the content for a short period of time while studying anywhere and at any time. Like the learning content, the activity needs to be suitable for presentation on a mobile device with a small screen. The aim of the activities is to develop learners' knowledge and skills through self-learning. Hence, it is vital that the activities must be designed to stimulate learners' interest and to promote optimum engagement from the learners. Some examples of microlearning activities include videos, interactive multimedia, games, short texts, infographics, and quizzes. The third principle specified that it should be usable and compatible with a variety of devices with small screens. Although the third design principle is not relevant to the context of this current study, the first and second design principles are useful in the design of a microlearning framework. It is essential that the duration for the microlearning element in a lesson is short and that the content should be relevant, concise, and easy for learners to comprehend. In addition, the activities should be stimulating and cognitively demanding to challenge learners to employ complex and critical thinking, thus resulting in self-learning. The microlearning approach should also engage learners in collaborative learning among their peers or community at large. Due to its nature of being bite-sized, microlearning allows learning to be integrated into learners' daily activities and can contribute to their lifelong learning.

In addition, McKee and Ntokos (2022) examined the effect of online microlearning on student engagement in computer games higher education. The study used a quasi-experimental design to compare two groups of students: one received microlearning-based instruction, and the other received traditional lecture-based instruction. The researchers found that microlearning-based instruction had a positive impact on student engagement, as measured by a survey and observations of student behaviour. The study also found that shorter video content had a greater impact on student engagement compared to longer videos. The researchers concluded that microlearning-based instruction can be an effective approach to improve student engagement in computer games higher education, and shorter videos may be more effective in promoting engagement among students.

## **Instructional Flow of the Lesson**

The second theme reveals the instructional flow of the microlearning lesson. Based on the SLR, in designing a microlearning lesson, several key aspects need to be considered, namely: (1) the learning objective of the lesson, (2) the use of different and attractive media formats, (3) the need to encourage interaction with peers, (4) practical exercises and hands on tasks, and (5) the need to provide instant feedback after or during the session.

Hesse et al. (2019) developed a set of protocols for online microlearning courses aimed training employees of dairy farms to improve their work performance. Even though the setting of the study was not in the context of higher education, the protocols can still shed some light on the design principles of the best pedagogical practices of microlearning in this current study. The microlearning course was structured into four parts: (1) learning objectives; (2) the standard operating procedure (SOP) (instruction), which included two parts (what you need and how to perform it); (3) relevant background information; and (4) assessment for self-evaluation. The learning objectives of the microlearning course set out what the participants ought to understand and be able to perform after finishing the course. The second protocol (SOP) in the study included images and a list of all materials required to complete the task, followed by a step-by-step description of the task with a title, image, and brief text beneath each image. The third protocol provided pertinent background information for each task. The course put forward eight questions to the learners where the aim was to allow the learners to gain additional knowledge related to the content at hand. The content was presented in the form of images, graphs, and short paragraphs. Finally, the learners were asked to complete a self-evaluation comprising questions pertaining to the content to measure the effectiveness of the course. This illustrates that assessment is an important element in the microlearning approach as it plays a critical role in the teaching and learning process. It offers valuable insight for both educators and students regarding the degree to which the students can accomplish the goals set out for them in the course. As a result, the assessment can help educators make instructional decisions and revise ineffective ones in their pedagogy. It can also provide feedback to students in terms of their strengths and weaknesses to support their learning. Additionally, it can give educators timely feedback so that they may adapt their instruction to the different learning styles of their students (Tosuncuoglu, 2018).

Similarly, Park and Kim (2018) explored the design and development of microlearning content in the e-learning system. The study presented various design and development strategies for the purpose of replacing current e-learning methods and creating personalised content that consider learners' learning time and environment. To utilise microlearning content in the existing curriculum as learning materials and to replace the regular curriculum with microlearning, the study highlighted several important factors to keep in mind. First, microlearning content development should be designed to have a single theme of the learning topic with a short unit; for example, a short interactive video not exceeding 10 minutes. Second, this study also highlighted the importance of developing microlearning contents that are relevant and appropriate to the context of the learners. Furthermore, when creating a course, it is crucial to determine the areas where improvements need to be made in existing courses or subjects. Additionally, it is important to simplify the technology employed by content developers, such as interface design and multimedia, to make it easier for instructors to produce content using the available resources.

Another guiding principle when developing microlearning content is the relevance of the content. The microlearning lesson needs to comprise contents that are relevant to the subject (Beste, 2021; Ten Cate et al., 2023). To assure high quality content of each microlearning lesson, it is important that the content is relevant and practical, and that it enforces a lesson that the students are familiar with to a certain degree (Paul, 2016). Therefore, the microlearning lessons can enhance students' understanding of the previous lesson(s) that they have learnt. Pascual et al. (2020) in their study demonstrated the effectiveness of the microlearning approach in enhancing students' learning performance. The study employed the use of TED talk videos, journal papers, and documentaries in the microlearning lessons. The study highlighted fundamental factors in choosing the materials for the microlearning lesson. First, the support material needs to reinforce the concepts that the students are already familiar with. Second, the materials should be derived from validated sources. Lastly, the materials should be considered as attractive materials for the targeted learners as the aim of the microlearning lesson is to spark students' interest and engage them further with the learning content.

Ten Cate et al. (2023) created microlearning for nurses and nursing assistants in both hospitals and home care environments with the aim

of promoting behavioural change based on several key principles, including interaction between the intervention and users, targeting users at both individual and group levels, supporting direct and seamless transfer to the workplace and continuous learning, enabling learning within a reasonable amount of time, and adapting to the context. In line with these principles, the research team focused on developing a microlearning intervention, and the results showed that the intervention had the potential to enhance the nutritional care of older adults in nursing. This highlights the significance of selecting microlearning materials that encourage interaction between the microlearning intervention and the learners, as well as designing microlearning tasks that allow for both individual and collaborative work among the learners.

## **DISCUSSION**

Based on the SLR, all articles that relate to the design and development of microlearning focused on the e-learning system. Previous studies had revealed several fundamental characteristics to design and develop a microlearning approach for an e-learning system or mobile microlearning platform. This shows that there is very limited empirical research available concerning the integration of the microlearning approach in classroom teaching and learning. Some of the reasons for this could be that microlearning is a relatively new but emerging trend in higher education (Leong et al., 2020). Skalka and Drlík (2018) concurred that there are very few studies on microlearning activities that can be used in educational settings. Meanwhile, Trowbridge et al. (2017) found that there are no clear guidelines for microlearning activities.

Shabadurai et al. (2022) further insisted that the perspective of microlearning and its content design is still unknown. Alqurashi (2017) also asserted that the existing microlearning framework lacks the pedagogy and technology aspect which are critical to effectively implement microlearning in the classroom. Sankaranarayanan et al. (2022) in his bibliometric analysis found that microlearning is poised to become a major research trend in education. Leong et al. (2021) also suggested that researchers should consider microlearning as a promising research area. Therefore, in reflecting on these gaps, there is a critical need to explore the pedagogical aspect of microlearning and the design pedagogical practices of microlearning which will assist

educators to effectively create and deliver the microlearning approach in teaching and learning. This present study sought to explore the design principles for pedagogical practices of microlearning for it to be embedded in higher education so that educators can apply microlearning as an instructional strategy to optimise teaching and learning in the classroom.

Based on the SLR, the pedagogical design of microlearning involves several key elements, including the design of microlearning content and instructional flow of the microlearning lesson. When designing microlearning content, it is important to consider the principles of instructional design of microlearning by breaking content down into smaller chunks, using clear and concise explanation, as well as providing opportunities for practice and feedback. To start, instructional design plays a crucial role in ensuring that microlearning experiences are engaging, relevant, and effective. This involves creating clear and concise learning objectives, identifying the most important information to be covered, and presenting the material in an engaging and easily digestible format. For example, instructional designers may use videos, animations, or interactive simulations to convey information, or they may incorporate gamification elements such as rewards or progress tracking to increase motivation and engagement.

Another key component that should be noted in the pedagogical design of microlearning is technology integration. This refers to the use of technology to deliver learning experiences, manage the delivery and assessment processes, and support learner engagement and interaction. For example, a learning management system (LMS) can be used to manage and deliver microlearning experiences, while social learning tools such as discussion forums or peer-to-peer feedback mechanisms can be used to encourage interaction and collaboration among learners. Additionally, technology can be used to track and analyse learning data to provide insights into the effectiveness of the microlearning experiences and inform future instructional design decisions.

Hills et al. (2022) in their study evaluated and compared various forms of education as well as their impact on medical staff's satisfaction. The findings from 81 responses indicated that medical professionals preferred the element of microlearning to be integrated in face-to-face and online teaching. This indicated that there is a demand to incorporate the microlearning element in the classroom. With regards

to the design of microlearning, this study indicated that the inclusion of interactive microlearning elements such as quizzes in traditional face-to-face classroom allows for better engagement of the learners as they can embark on short period learning activities according to their own preferred time and place.

It is undeniable that microlearning as a modern learning approach has the capabilities of providing students with numerous benefits and can lead to effective learning experiences. Indeed, in this era of higher education massification, more students are struggling than ever before. Microlearning aims to address this problem of cognitive overload, which is one of the major challenges faced by students today, by decreasing the amount of information and making learning materials more appealing and interactive (Korstange et al., 2020). Successful learning necessitates that knowledge is acquired on a regular basis and is retained for as long as possible. However, the problem with today's learning system is that learners frequently become stuck and lose interest and motivation in a traditional chalk and talk classroom. Hence, microlearning is a new teaching paradigm that allows knowledge and information to be broken down into little segments, making them more convenient and engaging for learners which in turn helps improve learners' comprehension on the subject matter and enhance knowledge retention for a longer period.

In order to meet the demands of a digital society, educational institutions must offer greater flexibility and personalisation, enabling learners to tailor their learning experience to their specific needs and life circumstances (Barnett, 2014). Higher education should promote flexible learning that accommodates the diverse needs of learners and empowers them to take more responsibility for their own learning process (Turan et al., 2022). Flexible learning places the learners and their needs at the centre. Educational services should give them the option to determine what, when, how, and where they want to learn (Higher Education Academy, 2015). Blended learning not only enriches classroom learning but also reshapes the learning environment to give learners more independence (Smith & Hill, 2019). Students should have the ability to learn independently, regardless of time and location, and have control over the content and pace of their learning (Müller & Mildenerger, 2021). The microlearning paradigm focuses on short, bite-sized content through the application of media and allows learners to learn at their own pace and time. By breaking down information into manageable chunks, incorporating social elements,

and taking advantage of the spacing effect and forgetting curve, microlearning provides learners with an effective way to learn and retain information. This approach to learning has become increasingly popular in recent years, as more and more people seek convenient and efficient ways to learn and improve their knowledge and skills. In conclusion, the pedagogical design of microlearning is a complex process that involves several key elements, including instructional design and technology integration. By considering these elements and aligning them with the learning objectives, instructional designers can create effective and engaging microlearning experiences that help learners achieve their goals and enhance their knowledge and skills.

## CONCLUSION

This systematic review of research on the pedagogical design of microlearning has highlighted two fundamental themes which are (1) the design of the microlearning content and (2) the instructional flow of the lesson. In designing the microlearning content, it is vital that the content is constructed in small, bite-sized and focused content that is relevant to the topic. Microlearning, being in the form of small, easily digestible pieces of information, enables learning to be seamlessly integrated into the daily lives of learners and can play a role in their lifelong education. Apart from that, in designing microlearning activities, it should be aligned with the learning objective of the lesson. Another crucial element of microlearning is the use of different and attractive media formats that encourage interaction with peers through practical tasks. Microlearning can be delivered in a variety of formats during the teaching and learning process, including video, application, gamification, infographics, and social media.

Several limitations exist within this study. First, there is a potential for language bias, as the search for relevant articles was restricted to those written in English. This decision may have excluded valuable studies published in other languages. Second, the period for this review was limited to articles published between 2014 and 2023. This restriction may have led to the exclusion of older studies that could have been pertinent to the research question. Lastly, the studies included in this review varied in terms of methodology, sample size, and intervention design. This heterogeneity of studies may have hindered the ability to compare and synthesize the findings accurately.

As microlearning gains increasing attention as a promising approach to enhancing learning outcomes in various educational settings, understanding how to design effective microlearning experiences has become a pressing issue for educators and instructional designers. This study addresses the gap in the literature by exploring the pedagogical design of microlearning and providing guidance and recommendations for practitioners in the field. With the rapid advancement of technology and the growing demand for flexible and personalised learning, microlearning has emerged as a potential solution to meet the diverse needs of learners. This research sheds light on how to effectively incorporate microlearning into educational practices, contributing to the ongoing conversation of the integration of technology in education. By providing new insights into the microlearning approach in educational settings, this study not only expands the theoretical understanding of microlearning but also has practical implications for designing effective and engaging learning experiences that can lead to improved learning outcomes.

In addition, the design principles and best practices for microlearning pedagogy identified in this study can be used by policymakers to create guidelines and standards for the integration of microlearning into the higher education curriculum. This can help ensure that microlearning is implemented in a systematic and effective manner, leading to improved learning outcomes that can better prepare students for the demands of the workforce. Additionally, policies can be developed to promote the use of microlearning to provide flexible and personalised learning experiences that can meet the diverse needs of learners. This can include initiatives to provide access to technology and resources necessary for the development and delivery of microlearning activities, as well as training and support for instructors to implement microlearning in their teaching. Overall, the findings and recommendations presented in this study can inform policy decisions related to the use of microlearning in education and contribute to the development of a more learner-centred and technology-enhanced educational system.

### **ACKNOWLEDGMENT**

This research was not funded by any specific grant from any public, commercial, or not-for-profit sectors. The authors declare no potential conflict of interest.

## REFERENCES

- Alqurashi, E. (2017). Microlearning: A pedagogical approach for technology integration. *International Educational Technology Conference*.
- Barnett, R. (2014). *Conditions of flexibility: Securing a more responsive higher education system*. Higher Education Academy, York, UK.
- Beste, T. (2021). Knowledge transfer in a project-based organization through microlearning on cost-efficiency. *The Journal of Applied Behavioral Science*, 59(2), 288–313. <https://doi.org/10.1177/00218863211033096>
- Buchem, I., & Hamelmann, H. (2010). Microlearning: A strategy for ongoing professional development. *eLearning Papers*, 1-15.
- Chai-Arayalert, S., & Puttinaovarat, S. (2020). Designing mangrove ecology self-learning application based on a micro-learning approach. *International Journal of Emerging Technologies in Learning*, 15(11), 29 - 41. <https://doi.org/10.3991/ijet.v15i11.12585>
- Choo, C. Y., & Abdul Rahim, A. S. (2021). Pharmacy students' perceptions and performance from a microlearning-based virtual practical on the elucidation of absolute configuration of drugs. *Asian Journal of University Education*, 17(4), 1-10. <https://doi.org/10.24191/ajue.v17i4.16187>
- Ebbinghaus, H. (1885). *Memory: A contribution to experimental psychology*. Teachers College Press.
- Fernandez, J. (2014). The micro learning trend: Accommodating cultural and cognitive shifts. *The Learning Guild*.
- Giurgiu, L. (2017). Microlearning an evolving elearning trend. *Scientific Bulletin*, 22(1), 18-23. <https://doi.org/10.1515/bsaft-2017-0003>
- Han, J. -L. (2019). Micro-lecture teaching for improving the learning effect of non-English majors at North China Electric Power University. *English Language Teaching*, 12(6), 209–216. <https://doi.org/10.5539/elt.v12n6p209>
- Hesse, A., Ospina, P., Wieland, M., Yepes, L., Nguyen, B., & Heuwieser, W. (2019). Short communication: Microlearning courses are effective at increasing the feelings of confidence and accuracy in the work of dairy personnel. *Journal of Dairy Science*, 102(10), 9505–9511. <https://doi.org/10.3168/jds.2018-15927>
- Higher Education Academy. (2015). Framework for flexible learning in higher education. *Advanced HE*. <https://www.advance-he.ac.uk/knowledge-hub/framework-flexible-learning-higher-education>

- Hills, M., Teoh, S. W. K., & Lebedevs, T. (2022). Evaluation of the effectiveness and staff acceptance of education strategies to improve medication safety. *Pharmacy Education*, 22(1), 428 – 435. <https://doi.org/10.46542/pe.2022.221.428435>
- Hug, T. (2005). Microlearning: A new pedagogical challenge. In T. Hug, M. Lindner, & P. A. Bruck (Eds.), *Microlearning: Emerging concepts, practices and technologies after e-learning* (pp. 7-12). Innsbruck University Press.
- Jahnke, I., Lee, Y. M., Pham, M., He, H., & Austin, L. (2020). Unpacking the inherent design principles of mobile microlearning. *Technology, Knowledge and Learning*, 25(3), 585-619. <https://doi.org/10.1007/s10758-019-09413-w>
- Jomah, O., Masoud, A. K., Kishore, X. P., & Aurelia, S. (2016). Micro learning: A modernised education system. *Broad Research in Artificial Intelligence and Neuroscience*, 7(1), 103-110. <https://lumenpublishing.com/journals/index.php/brain/article/view/1986>
- Kadiev, A., Tan, E., & Specht, M. (2021). An evaluation framework for microlearning tools for designing and delivering microlearning content. Delft University of Technology. <http://resolver.tudelft.nl/uuid:819700a5-b1fa-4ae3-86cd-f2c242092f63>
- Kasuma, S. A. A., Akhlar, A., Haron, H., Fesal, S. N. H. S., & Kadir, N. F. A. (2021). University students' perceptions of motivation, attitude, and self-efficacy in online English language learning. *Pertanika Journal of Social Science & Humanities*, 29(4), 2763-2784. <https://doi.org/10.47836/pjssh.29.4.36>
- Kerres, M. (2007). Microlearning as a challenge for instructional design. In T. Hug & M. Lindner (Eds.), *Didactics of microlearning. concepts, discourses and examples* (pp. 98-109). Waxmann.
- Korstange, R., Hall, J., Holcomb, J., & Jasmeial, J. (2020). The online first-year experience: Defining and illustrating a new reality. *Adult Learning*, 31(3) 95-108. <https://doi.org/10.1177/1045159519892680>
- Kovachev, D., Cao, Y., Klamma, R., & Jarke, M. (2011). Learn-as-you-go: New ways of cloud-based micro-learning for the mobile web. *Advances in Web-Based Learning*, 51-61. [https://doi.org/10.1007/978-3-642-25813-8\\_6](https://doi.org/10.1007/978-3-642-25813-8_6)
- Leong, K., Sung, A., Au, D., & Blanchard, C., (2021). A review of the trend of microlearning. *Journal of Work-Applied Management*, 13(1), 88-102. <https://doi.org/10.1108/JWAM-10-2020-0044>

- Lindner, M. (2006). Use these tools, your mind will follow. Learning in immersive micromedia & microknowledge environments. *In The Next Generation: Research Proceedings of the 13th ALT-C Conference*, 41-49.
- McKee, C., & Ntokos, K. (2022). Online microlearning and student engagement in computer games higher education. *Research in Learning Technology*, 30(2680). <https://doi.org/10.25304/rlt.v30.2680>
- Mohamed, R., Ghazali, M., & Samsudin, M. A. (2020). A systematic review on mathematical language learning using PRISMA in Scopus database. *Eurasia Journal of Mathematics, Science and Technology Education*, 16(8), <https://doi.org/10.29333/ejmste/8300>
- Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. The PRISMA Group (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA Statement. *PLoS Med*, 6(7). <https://doi:10.1371/journal.pmed100009>
- Müller, C., & Mildenerger, T. (2021). Facilitating flexible learning by replacing classroom time with an online learning environment: A systematic review of blended learning in higher education. *Educational Research Review*, 34(100394). <https://doi.org/10.1016/j.edurev.2021.100394>
- Park, Y., & Kim, Y. (2018). A design and development of micro-learning content in e-learning system. *International Journal on Advanced Science, Engineering and Information Technology*, 8(1). <http://dx.doi.org/10.18517/ijaseit.8.1.2698>
- Pascual, R., Blanco, E., Viveros, P., & Kristjanpoller, F. (2020). Application of microlearning activities to improve engineering students' self-awareness. *International Journal of Engineering Education*, 36(6), 1894-1904.
- Paul, A. M. (2016). Microlearning 101. *HR Magazine*, 61(4), 36-40.
- Polasek, R., & Javorcik, T. (2019). Results of pilot study into the application of microlearning in teaching the subject computer architecture and operating system basics. *International Symposium on Educational Technology*, 196-201. <https://doi.org/10.1109/ISET.2019.00048>
- Salleh, D., Khairudin, N., & Ibrahim, M. (2022). Micro learning: Motivating students' learning interests. *Jurnal Psikologi Malaysia*, 36(1), 153-162.
- Sankaranarayanan, R., Leung, J., Abramenka-Lachheb, V., Seo, G., & Lachheb, A. (2022). Microlearning in diverse contexts: A bibliometric analysis. *TechTrends*, 67, 260-276. <https://doi.org/10.1007/s11528-022-00794-x>

- Shabadurai, Y., Chua, F. F., & Lim, T. Y. (2022). Investigating the employees' perspectives and experiences of microlearning content design for online training. *International Journal of Information and Education Technology*, 12(8), 786-793. <https://doi.org/10.18178/ijiet.2022.12.8.1685>
- Skalka, J., & Drlik, M., (2018). Conceptual framework of microlearning-based training mobile application for improving programming skills. *Interactive Mobile Communication Technologies and Learning*. [https://doi.org/10.1007/978-3-319-75175-7\\_22](https://doi.org/10.1007/978-3-319-75175-7_22)
- Smith, K., & Hill, J. (2019). Defining the nature of blended learning through its depiction in current research. *Higher Education Research and Development*, 38(2), 383-397. <https://doi.org/10.1080/07294360.2018.1517732>
- Ten Cate, D., Dikken, J., Ettema, R. G. A., Schoonhoven, L., & Schuurmans, M. J. (2023). Development of a microlearning intervention regarding nursing nutritional care for older adults: A multi-methods study. *Nurse Education Today*, 120, 105623. <https://doi.org/10.1016/j.nedt.2022.105623>
- Thillainadesan, J., Le Couteur, D. G., Haq, I., & Wilkinson, T. J. (2022). When I say ... microlearning. *Medical Education*, 56(8), 791–792. <https://doi.org/10.1111/medu.14848>
- Tosuncuoglu, I. (2018). Importance of assessment in ELT. *Journal of Education and Training Studies*, 6(9), 163-167. <https://doi.org/10.11114/jets.v6i9.3443>
- Trowbridge, S., Waterbury, C., & Sudbury, L. (2017, April 10). Learning in bursts: Microlearning with social media. *Educause Review*. <https://er.educause.edu/articles/2017/4/learning-in-bursts-microlearning-with-social-media>
- Turan, Z., Kucuk, S., & Cilligol Karabey, S. (2022). The university students' self-regulated effort, flexibility and satisfaction in distance education. *International Journal of Educational Technology in Higher Education*, 19(35). <https://doi.org/10.1186/s41239-022-00342-w>
- Wang, T., Towey, D., Ng, R. Y., & Gill, A. S. (2021). Towards post-pandemic transformative teaching and learning: Case studies of microlearning implementations in two post-secondary educational institutions. *SN Computer Science*, 2(4), 271. <https://doi.org/10.1007/s42979-021-00663-z>
- Zarshenas, L., Mehrabi, M., Karamdar, L., Keshavarzi, M. H., & Keshtkaran, Z. (2022). The effect of micro-learning on learning and self-efficacy of nursing students: An interventional study. *BMC Medical Education*, 22(664). <https://doi.org/10.1186/s12909-022-03726-8>