A systematic review of mobile-based microlearning in adult learner contexts

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ABSTRACT: This systematic review examines the empirical literature published between 2015 and 2021 on mobile-based microlearning in adult learning contexts. The rapid shift to online learning in 2020 in response to the global COVID-19 pandemic has emphasized the need to explore flexible learning options for adult learners. The convenience of mobile-based learning has increased due to the prevalence and global access to mobile devices. Mobile-based microlearning is an emerging area of research, and in this systematic review we explore ways adult learning contexts – including workplace and higher education – have integrated mobile-based microlearning to support instructional goals. We synthesize nine articles about mobile-based microlearning highlighting findings and implications for facilitators. Our findings showed that mobile-based microlearning is being implemented in various instructional contexts and the included studies focused on effectiveness and design principles. We conclude our review with recommendations for implications for practice.

Keywords: Microlearning, Mobile-based microlearning, Just-in-time training

1. Introduction

Mobile-based microlearning has become popular in the workplace and higher education settings (Lee et al., 2021; Leong et al., 2021; Zhang et al., 2016). This approach leverages the convenience of mobile devices and provides learners with immediate access to the essential training and resources necessary to achieve their goals efficiently. By breaking content into smaller chunks, it allows for rapid retrieval of information, which is critical in contexts such as information technology, the medical field, or other workplaces (Dabbagh & Fake, 2017; Gerbaudo et al., 2021; Lee, 2021; Smith et al., 2020). Wen and Zhang (2015) explain that microlearning can provide selective and personalized learning according to students' needs, enabling them to learn and fill in knowledge gaps. An essential aspect of microlearning is smaller content sizes and the learner's ability to interact with the content (Epp & Phirangee, 2019; Gerbaudo et al., 2021; Voss, 2021). Developing competency is particularly critical in workplace settings where workers must constantly maintain and refine their competencies (Gerbaudo et al., 2021; Moore, 2020; Zhang et al., 2016). Moreover, the time and speed of learning can be adjusted to individual learners, improving their retention and recall (Bruck, 2006).

Microlearning is not a new concept, and mobile-based microlearning is an evolution of the approach that has aligned with the prevalence and technological advances of mobile-based devices such as smartphones and tablets. Lin (2023 predicts there will be more than 7.5 billion smartphone users by 2026. Mobile-based microlearning combines the advantages of mobile learning and microlearning (Lee et al., 2021; Nikou & Economides, 2018), allowing personalized, adaptive, ubiquitous, and context-aware instruction (Bruck et al., 2012). Mobile-based microlearning has gained popularity for its ability to deliver skill-based information when needed (Bruck, 2006; Gerbaudo et al., 2021; Jahnke et al., 2020; Lee et al., 2021). The format of mobile-based microlearning can take many forms, including reflection, performance support, goal reminding, and task assignments (Gerbaudo et al., 2021; Taylor & Hung, 2022; Thalheimer, 2017; Voss, 2021). Moreover, in mobile-based microlearning, the content can be personalized, adaptive, and context-aware through the small screens of smartphones (Bruck et al., 2012). Studies show that mobile-based microlearning improves learners' efficiency, performance, engagement, and teaching approaches (Aitchanov et al., 2018; Dai et al., 2018; Göschlberger & Bruck, 2017; Jahnke et al., 2020; Ma, 2016). For adults and workers, mobile-based microlearning may provide increased flexibility to apply factual knowledge to skills required for the job (Decker et al., 2017).

As with any instructional approach, there are challenges with using mobile-based microlearning. For example, presenting too much information on small screens can result in eye strain (Sharma & Singh, 2022). In terms of learning effectiveness, using a mobile device may distract the learner, given the opportunities for misuse for other purposes such as enjoyment (Abdelaziz, 2020; Andoniou, 2017). Other pitfalls exist with technology, accessibility, and affordability (Jahnke et al., 2020). In addition, adopting new technology can be challenging for teachers or instructors unfamiliar with the digital environment because it requires time-consuming technical skills (Moore, 2016a; Oyarzun et al., 2020). This systematic review aims to synthesize the empirical research focusing specifically on workplace and higher education settings, which need more research attention.

1.1. Prior systematic reviews

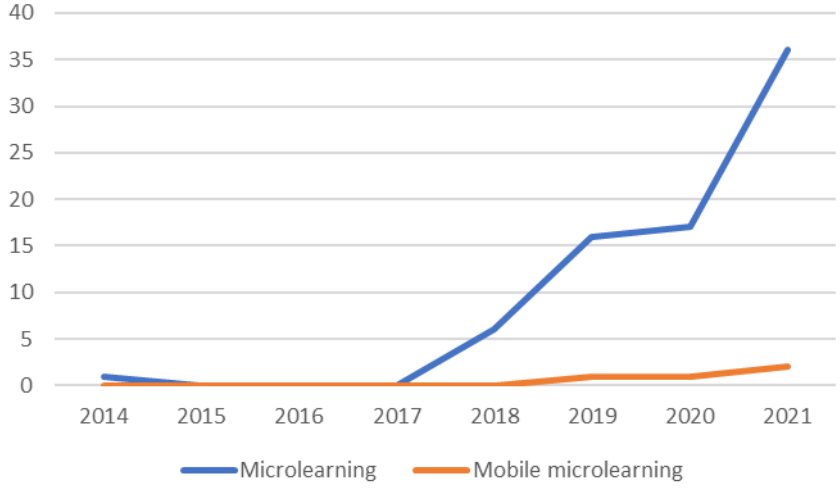
Our work builds off previous work focused on microlearning (Jahnke et al., 2020; Lee, 2021; Taylor & Hung, 2022) with a few key differences. Jahnke's et al. (2020) systematic review focused on microlearning's design challenges and principles. Jahnke et al. searched 2013-2017 and included 50 articles across five databases with conference proceedings. They also looked at academic articles as well as industry literature. In their review, they synthesized 15 design principles included in mobile microlearning, spanning usability issues and instructional flow. While this was an important focus, we were particularly interested in learner outcomes.

While Taylor and Hung (2022) were also interested in adult contexts, they did not include "mobile-based" as part of their search strings. Taylor and Hung sought to determine the trends and effects of microlearning. This search was conducted in 11 databases from years 2009-2020 and included 13 peer-reviewed articles. These 13 articles were then further classified into three categories of microlearning: short lessons, just-in-time (JIT), and flash lessons; all employed a range of instructional strategies including demonstration, gamification, and question and answers. They discovered that microlearning has apparent effects on knowledge and skills acquisition, increased learner confidence, and an increased utilization of microlearning materials beyond their required use. However, they omitted "mobile-based" as part of their search strings, stating that most microlearning was not designed to fit small screen mobile devices.

Lee's (2021) systematic review included K-12 contexts and excluded studies that used tablets and iPads. Lee's review included 26 articles from five academic databases and examined the purpose, source, impact, setting, and outcomes of the 26 mobile microlearning articles. Results of the review indicate an increase in student performance and motivation with a notable increase in knowledge retention. While this information is valuable, Lee only explored K-12 contexts and excluded studies that used tablets and iPads. Our review aims to discover any advances in microlearning since this previous work within the use of mobile devices and tablets.

Global smartphone usage is exploding, and the convenience of content and instructional materials in mobile formats addresses equity and access issues (Lin, 2023; Statista, 2023). The prior systematic reviews about microlearning omitted the critical mobile-based context or only looked at it in K-12 contexts. We acknowledge the instructional and design challenges of delivering content for small screens, but do not consider this an insurmountable challenge. We found that the interest in microlearning is trending upwards as evidenced by the increase in publications starting around 2017 (Figure 1). While the number of publications focused on mobile-based microlearning is increasing slower, we attribute part of that to the lack of understanding of the design challenges and implementation approaches for mobile-based microlearning. Global smartphone usage will only expand in the coming years, and course facilitators and designers need to understand ways of leveraging these devices for instructional purposes.

Figure 1. Microlearning and mobile-based microlearning publications (Source: Web of Science)



1.2. Purpose

To address the lack of understanding around implementation approaches for mobile-based microlearning, we conducted a systematic review to examine mobile-based microlearning in adult contexts – specifically in the workplace or higher education. We were interested in how adult learners use mobile-based microlearning to

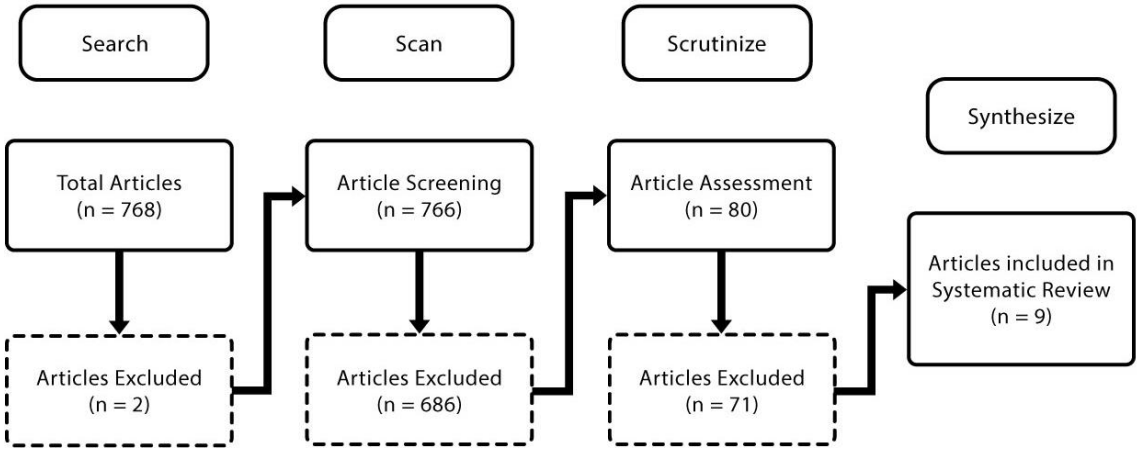
support their learning objectives. We also wanted to extend the prior work that has been done and provide synthesis on several aspects, specifically best practices for implementing mobile-based microlearning. We intend our findings to be helpful for those considering this approach and to encourage additional empirical research on implementations in various contexts. We selected a start date of 2015 to align with the increases in global mobile device usage (Lin, 2023; Statista, 2023), the upward trend of microlearning publications (Figure 1 above), and prior systematic reviews (Lee et al., 2021). Our systematic review will answer the following questions:

- In what instructional contexts or settings has mobile-based microlearning been implemented?
- What are the key findings from the implementations?

2. Methods

We conducted a systematic review of empirical articles to answer our research questions and used the PRISMA principles (Liberati et al., 2009) to guide the article selection process (Figure 2). Following the PRISMA guidelines allows for a transparent article selection process and establishes trustworthiness (Moore & Miller, 2022; Page et al., 2021).

Figure 2. Article selection process



2.1. Search

Our search was conducted in September 2022 using the Academic Search Premier and Education Source databases to identify peer-reviewed articles published between 2015 and 2021 with the following search strings: (“micro*” OR “just in time” OR “just-in-time”) AND (“mobile*”) AND (“workplace*” OR “train*” OR “learn*”). The “*” is used for wildcard searches. We defined “mobile” as any hand-held device including smartphones and tablets. These databases are commonly used for education-focused systematic reviews (Moore, 2020; Moore et al., 2023). These searches returned 768 studies, and we removed two duplicates, leaving us with 766 remaining.

2.2. Scan

We focused our systematic review on peer-reviewed empirical articles. We did not consider dissertations or conference proceedings for this review. When crafting the search strings for a systematic review, broad terms are helpful because it is not always clear how an author would define a specific term. During this second phase, we can scan the abstracts and filter down to the contexts we are most interested in. Our focus was on adult learners and we removed abstracts that either did not focus on adult learners (e.g., K-12 contexts) or were not about mobile-based microlearning. We used a broad definition of mobile in the search and then reviewed how microlearning was used to ensure it was on a mobile device. The latter focus resulted in most articles being excluded at this stage. Other common reasons included being a systematic review, not in the adult learner contexts, or not microlearning. This process removed 686 articles.

2.3. Scrutinize

There are typically two ways that articles are evaluated for quality – one is by filtering the initial search to specific high-quality journals (Crompton & Burke, 2018; Martin et al., 2020; Moore, 2022) and the other is by filtering screened abstracts by Q1 or Q2 journals (Bano et al., 2018; Moore, 2020; Moore et al., 2023). We decided to use the latter approach to ensure high-quality peer-reviewed research and narrowed our pool to only include articles published in Q1 or Q2 journals as ranked by SCImago (https://www.scimagojr.com/journalrank.php). The SCImago rankings use information from the Scopus database. This narrowing removed 28 articles from the pool. At least two authors reviewed each of the remaining articles based on the inclusion and exclusion criteria (Table 1). The first author resolved any conflicts, and collaboratively, all three authors reached a consensus on each article. Ultimately, we removed 43 articles – 22 were not about educational contexts, 16 were not about mobile-based microlearning, and five were not empirical. This final removal left nine articles that are included in our study.

Table 1. Inclusion and exclusion criteria

INCLUDE if ALL the following TRUE	EXCLUDE if ANY of the following TRUE
Published in English	The result is a dissertation, conference proceeding, or other non-peer-reviewed source.
Published between 2015 and 2021	The study provides insufficient details on the connection between mobile-based microlearning and an instructional context.
Published in a Q1 or Q2 peer-reviewed journal*	
Empirical study focusing on mobile-based micro-learning in the workplace or higher education contexts.	

Note. *Source: SCImago Journal and Country rankings (https://www.scimagojr.com/journalrank.php)

2.4. Synthesize

The results of synthesizing the nine articles are discussed in the following sections. Five of the articles measured specific learning outcomes (Joynes & Fuller, 2016; Lee et al., 2021; Wang et al., 2020; Wen & Zhang, 2015; Zhang et al., 2016), while four others focused on student perceptions of the design or usability of the microlearning technology (Dabbagh & Fake, 2017; Gerbaudo et al., 2021; Neffati et al., 2021; Voss, 2021). Because we used "mobile-based" as one of our filter requirements, we use microlearning and mobile-based microlearning interchangeably in the preceding sections. Where appropriate, we have added additional context through citations.

3. Results

We searched for empirical peer-reviewed articles published between 2015 and 2021 that investigated the support of educational goals – in both workplace and higher education contexts – through the integration of mobile-based microlearning. 2016 and 2021 were the most common publication years, with none published during 2018 or 2019. The recent trend of publications in 2021 suggests that mobile-based microlearning is an emerging educational concept and will continue to be researched and investigated. The publications were in various outlets, including journals focused on STEM (engineering, microprocessors, physics), medical, music, and educational technology contexts.

3.1. RQ1: In what instructional contexts or settings has mobile-based microlearning been implemented?

The included studies showed the diversity of contexts in which mobile-based microlearning has been implemented (see Table 2).

The implementation of mobile-based microlearning in undergraduate physics courses (Wang et al., 2020), computer software courses (Wen & Zhang, 2015), and medical education (Neffati et al., 2021) highlights potential applications for enhancing learning experiences across various disciplines. One significant advantage of mobile-based microlearning is the provision of on-demand resources, particularly beneficial in workplace environments (Gerbaudo et al., 2021; Zhang et al., 2016). This demonstrates that mobile-based microlearning can address individuals' specific learning needs and challenges in professional settings. Mobile-based

microlearning in clinical and medical settings (Joynes & Fuller, 2016; Neffati et al., 2021) indicates its potential for improving medical education and enhancing clinical curriculum resources. Examining how faculty and instructional designers can benefit from microlearning resources (Dabbagh & Fake, 2017) suggests that mobile-based microlearning approaches can also support educators and instructional designers enhance their teaching practices and design practical learning resources.

Table 2. Contexts for included articles

Context	Article(s)
STEM Courses	Wang et al., 2020; Wen & Zhang, 2015
Workplace	Gerbaudo et al., 2021; Zhang et al., 2016
Clinical and Medical	J oynes & Fuller, 2016; Neffati et al., 2021
Journalism Courses	Lee et al., 2021
Music Courses	Voss, 2021
Faculty and Instructional Designers	Dabbagh & Fake, 2017

Each included study involved the development of a platform or curating resources into a repository to be implemented and used by the target audience. This development included courses (Lee et al., 2021), mobile platforms (Wang et al., 2020; Wen & Zhang, 2015; Zhang et al., 2016), mobile apps (Dabbagh & Fake, 2017; Neffati et al., 2021), and curated resources (Gerbaudo et al., 2021; Voss, 2021). Wang et al. (2020) focused their implementation in an undergraduate physics course. Wen and Zhang (2015) designed a microlecture platform to support learners in computer software courses. Notably, one of the advantages of microlearning is the ability to provide on-demand resources which can be particularly helpful in workplace environments (Gerbaudo et al., 2021; Zhang et al., 2016). Zhang's et al. (2016) study focused on designing a work-based learning platform for factory or office settings, and Gerbaudo's et al. (2021) study focused on creating a media platform for IT professionals. The clinical and medical settings were explored (Joynes & Fuller, 2016; Neffati et al., 2021). Neffati et al. (2021) developed a mobile e-learning app for medical education, and Joynes and Fuller (2016) developed microlearning resources for a clinical curriculum. Lee et al. (2021) described how they developed a mobile microlearning course for journalism students. Voss (2021) explored how just-in-time resources could be implemented to support students learning about music production. Dabbagh and Fake (2017) examined how faculty and instructional designers could benefit from microlearning resources.

3.2. RQ2: What were the key findings from the implementations?

Overall, the implementations were positively received in each of the studies. We found two themes of effectiveness—design principles and behaviors—in the articles (Table 3).

Table 3. Implementation themes of included articles

Theme	Articles
Effectiveness	Lee et al., 2021; Wang et al., 2020; Wen & Zhang, 2015; Zhang et al., 2016
Design Principles	Dabbagh & Fake, 2017; Gerbaudo et al., 2021; Joynes & Fuller, 2016; Neffati et al., 2021; Voss, 2021; Zhang et al., 2016

3.2.1. Effectiveness of mobile-based microlearning

Several of the included studies focused on the effectiveness of mobile-based microlearning (Lee et al., 2021; Wang et al., 2020; Wen & Zhang, 2015; Zhang et al., 2016). Wang et al. (2020) found that their mobile-based microlearning intervention for college physics content improved final exam mean scores and exam pass rate for students compared to the control group only receiving face-to-face teaching. Lee et al. (2021) confirmed that a mobile micro-course appealed to learners, improved their test scores, reduced the guessing rate, and enhanced learners' self-efficacy in news writing skills. Zhang et al. (2016) found that 84% of participants completed a work-based mission with a newly designed mobile system (WoBaLearn) for work-based learning. Furthermore, when the learners were assigned to redo the mission one week later, all participants who had completed the first mission could recall and succeed again. Wen and Zhang (2015) concluded that introducing Microlecture Mobile Learning System (MMLS) decreased course difficulty and increased interest and intelligibility in computer software courses. Additionally, the learners in MMLS exhibited higher average scores in the final exam compared to learners in the classroom.

3.2.2. Design principles in various contexts

Another emerging theme focused on design principles of mobile-based microlearning (Dabbagh & Fake, 2017; Gerbaudo et al., 2021; Neffati et al., 2021; Voss, 2021; Zhang et al., 2016). Gerbaudo et al. (2021) proposed a new online video model following Design Thinking methodology. The study respondents evaluated the enhanced video format as superior to other videos when learning how to solve IT problems. Neffati et al. (2021) designed an Augmented Reality platform for software engineering learners. In certain studies, contextualization in system design for personalization was emphasized. Zhang et al. (2016) described the system design, implementation, and evaluation methods and results of a work-based learning mobile system (WoBaLearn). Their focus was on a context-aware mobile learning system that enables personalization and adaptation processes for learners. Dabbagh and Fake (2017) attempted to design a mobile recommender system to align instructional strategies with learning technologies, targeting instructional designers and faculty. They noted different organizations may have different contextual needs that should be further explored. Voss (2021) designed a mobile application where just-in-time learning was provided for music recording production. This pilot study derived six design principles: task specific, concise, contextual, visual, diverse, and integrated. Joynes and Fuller (2016) investigated the impact of mobile learning resources in a mobile learning program (MBChB Mobile). In the program, mobile learning was a compulsory part of the course to maximize students' engagement, and the analysis showed that social and cultural norms can influence mobile behaviors. However, the authors caution that microlearning resources must complement, not replace, paper-based resources.

4. Discussion

This section provides the implications for practice that emerged from the included studies.

4.1. Implications for practice

Mobile-based microlearning offers many advantages, but implementing and developing this type of learning requires careful planning on the instructor's part. Mobile-based microlearning will require many of the same considerations that course designers need to consider when developing online courses (Moore, 2016a; Oyarzun et al., 2020). Creating a comprehensive microlearning curriculum or platform can require significant effort, particularly if it involves developing a new platform (Wang et al., 2020; Wen & Zhang, 2015; Zhang et al., 2016). Using a pilot approach and starting small in developing and using mobile-based microlearning can be useful. Instead of creating an entire course, consider doing one section or activity, engaging students in feedback, and building upon those efforts (Moore, 2016a; Moore, 2016b; Oyarzun et al., 2020). This approach allows an iterative design process that can focus on a specific topic or learning objective, ensuring that the microlearning content is concise, targeted, and aligned with the desired learning outcomes. By implementing the microlearning intervention and seeking input from learners, facilitators can assess the approach's effectiveness, identify areas for improvement, and gain insights that can inform future iterations and refinements of the microlearning resources. This iterative process allows for continuous improvement and ensures that subsequent microlearning modules or lessons are more tailored and to the learners' needs. This approach enables more efficient resource allocation, better alignment with learning outcomes, and informed decision-making for future scalability and implementation efforts (Moore, 2016b). The implications of this research highlight the potential of mobile-based microlearning in diverse contexts, including various disciplines, workplace environments, clinical and medical education, journalism education, music production education, and supporting educators and instructional designers. The findings underscore the adaptability and versatility of microlearning in meeting the specific learning needs of different target audiences. Based on these implications and findings, we encourage course facilitators to consider how they can use microlearning to complement existing instruction and personalize feedback to learners as they engage with this content.

4.1.1. Complement existing instruction

When considering the content to be used with microlearning, course facilitators should consider how it can complement existing instruction. Mobile-based learning presents opportunities for linking the instruction to authentic contexts (Lee et al., 2021; Wen & Zhang, 2015) which has been shown to be particularly effective for online instruction (Lowell & Moore, 2020; Moore, 2016a; Oyarzun et al., 2020). By framing the mobile-based content as complementary content, learners can fill their knowledge gaps at a time that is most convenient to them (Dabbagh & Fake, 2017; Voss, 2021; Wen & Zhang, 2015). This will maximize the effectiveness of

mobile-based learning as learners are able to take advantage of the just-in-time nature of these complementary resources (Gerbaudo et al., 2021; Voss, 2021). A key advantage of microlearning is that it provides learners with greater autonomy and flexibility in choosing their preferred method of receiving instruction. Allowing learners to select the microlearning modules or resources that align with their needs and preferences makes them more engaged and motivated, leading to improved learning outcomes (Epp & Phirangee, 2019; Wen & Zhang, 2015). Moreover, using microlearning as a complementary resource can enhance the accessibility and variety of learning materials.

4.1.2. Personalizing feedback

Pairing the just-in-time access to the information also creates opportunities to provide adaptive and personalized feedback to learners (Lee et al., 2021). This convenience makes the content available exactly when the learner needs it, and where possible, automated feedback should be implemented. This feedback will ensure that learners make the necessary connections between knowledge acquisition and their application to practice (Gerbaudo et al., 2021; Korkmaz & Boling, 2014; Lee et al., 2021). And while automated feedback can be valuable, personalizing the feedback to learners can help them adjust their learning behaviors (Lee et al., 2021). This personalized feedback considers each learner's specific needs, strengths, and areas for improvement, enhancing their engagement, motivation, and understanding of the content. By leveraging microlearning to deliver personalized feedback, educators can create a more individualized learning experience that promotes meaningful and targeted learning outcomes.

5. Limitations

A systematic review reflects the authors' decisions from framing the research questions through the article filtering decisions. To establish the validity of the systematic review, we implemented the PRISMA guidelines (Liberati et al., 2009; Page et al., 2021). These guidelines allow for a transparent search and article selection process that ensures future researchers can extend our work. A limitation of our research is our reliance on peer-reviewed sources. Another limitation was our criteria for high-quality articles and basing that on the ratings of the journals. While this did remove several articles, we felt that this approach was essential to aid in synthesizing high-quality work. We encourage other researchers to consider ways to evaluate article quality and refine our inclusion and exclusion criteria as they see fit. As indicated by the Web of Science publication report, there is growing interest in microlearning, and we wanted to establish a baseline for mobile-based microlearning synthesis. As more articles that focus on mobile-based microlearning are published in the coming years, researchers will have more opportunities to categorize and distill the research literature. While we found many articles referencing "mobile-based" and "microlearning" in titles and abstracts, our scan found that many lacked detailed focus on the learner outcomes or were not situated in adult learning contexts. This lack of focus suggests that while microlearning has broad interest, the research on mobile-based microlearning is still nascent in educational contexts.

6. Conclusion

This systematic review examined how mobile-based microlearning has been implemented in higher education and workplace contexts. We found that the flexibility of mobile devices has allowed for creative and innovative ways to provide just-in-time resources to learners across various contexts. Mobile-based microlearning has been used in academic and professional settings and fields of medicine, IT, music, instructional design, journalism, and physics, among others (Dabbagh & Fake, 2017; Gerbaudo et al., 2021; Lee et al., 2021; Neffati et al., 2021; Voss, 2021; Wang et al., 2020). All the articles showed evidence of a gain in learner outcomes or a positive impact on student perceptions of the technology. The number of 2021 articles in our study suggests a growing interest in mobile-based microlearning in higher education and professional settings. We invite future researchers to continue to empirically explore how microlearning can provide opportunities to support the diversity of adult learners' needs.

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