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RESEARCH ARTICLE

The Effects of Microlearning: A Scoping Review

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Abstract
Microlearning has gained popularity in both the training industry and professional studies disciplines over the last several years. While substantial information exists in industry articles and commentaries on the definition of microlearning—along with how to create, develop, and implement it—a closer look at the existing research is important. Further study is needed to understand how to inform instructional design professionals of current trends and the effects of microlearning training on the enhancement of learner performance in both workplace and academic settings. Thus, this scoping review aims to examine the literature and identify noticeable trends, patterns, and evidence of how microlearning has been used and implemented in both academic learning and industry training settings.

Keywords Microlearning · Adult education · Scoping review · Learning environments · Instructional design

Introduction

The concept of microlearning has gained popularity in the training and learning industry and professional studies disciplines over the last several years (BasuMallick, 2018; Göschlberger & Bruck, 2017; Giurgiu & Bălcescu, 2017; Gutenberg Technology [GT], 2019; Oesch, 2017; Pandey, 2019; Seidel, 2018). The rise of internet social media has changed people's information-seeking and consuming behaviors, which gears their preference toward single, discrete topics that are presented in a short duration to meet their moment of learning need. To satisfy such preferences, companies are providing resources and information to promote use of the microlearning approach in the workforce (Andriotis, 2018a; BasuMallick, 2018; Selko, 2019; Smith, 2016). At present, microlearning is still an emerging and evolving instructional approach; thus, a standard definition or format does not yet exist. However, generally speaking, microlearning may be described as "a form of e-learning delivered in small chunks, focused on delivering skill-based and just-in-time knowledge" (JIT) (Zhang & West, 2020, p. 310).

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JIT knowledge can be defined as "delivering the right knowledge at the right time" (Wilkie, 2013, p. 3). Some microlearning instructions may resemble casual, discrete (non-systematic) learning events, for example, a quick search on YouTube for how to use a multimeter. This method is supported by reports and research on millennium generations—from elementary school students (Hassinger-Das et al., 2020) to medical students (Van den Eynde et al., 2019)—which show that this age group prefers learning from YouTube videos over traditional textbooks or even videos on TV (Genota, 2018; Hassinger-Das et al., 2020). Other microlearning instructions are more structured and serve as a supplemental part of a course or curriculum (De Gagne et al., 2019).

Microlearning instruction can be delivered in the form of videos, documents, screencasts, and other varieties of learning created and deployed by learning professionals. This instruction may also be developed by peers as user-generated content. Microlearning also can be delivered via web-based or mobile platforms, which may be categorized under mobile learning—instruction and student–teacher interactions taking place through mobile devices and wireless communication (Chung et al., 2019). This instructional approach provides a ubiquitous learning environment and is the primary delivery format of microlearning to meet the demands for quick and easy access of information in need. The creation of microlearning continues as the demand and consumption of microlearning increases. According to microlearning researchers (e.g. Andriotis, 2018b; De Gagne et al., 2019; Zambito, 2018), while this type of instruction varies in format and instructional purpose, it provides bite-sized amounts of information that are easily and quickly consumed, learner-driven, and on-demand in nature.

Along with the interest in microlearning is the assumption that creating more microlearning courses will address workplace performance and perhaps higher education challenges. The assumed reasoning is that by providing shorter and more focused content according to need, the information is easier to consume and retain from the learner's perspective (Gutierrez, 2018; Sanal, 2019). Also, the purpose of the bite-sized course content is to reduce the cognitive load on working memory (Sweller, 1988) for effective learning. Furthermore, short instruction is also a motivating element of this instructional approach as it encourage students to review the content multiple times, and thus, it increases retention (e.g., Gagné & Briggs, 1979). The promises of microlearning are enthusiastically promoted by the advocates, yet the effectiveness of microlearning on intended outcomes is unclear. Ample information appears to exist in industry articles and commentaries on the definition of microlearning and how to create, develop, and implement it. However, not much supporting evidence is apparent in the literature as to microlearning trends and the effects of microlearning training on the enhancement of learner performance in both workplace and academic settings.

While they carry promising instructional benefits and motivating factors and are advocated by many enthusiastic training professionals (Andriotis, 2018a; BasuMallick, 2018; Oesch, 2017; Pandey, 2019; Seidel, 2018; Selko, 2019; Smith, 2016; Zambito, 2018), these assumptions are still yet to be scrutinized. Thus, this scoping review aims to examine the related literature and identify noticeable trends, patterns, and evidence of how microlearning has been used and implemented in both academic learning and industry training settings. More importantly, determining the effectiveness of the methodology in meeting the needs of learners and trainees as well as enhancing their performance is also the goal of this review.

Method

This study uses Arksey and O'Malley's (2005) scoping study methodology framework to investigate trends of employing microlearning for learning and training purposes in higher education and workplace environments, along with the effects of microlearning on enhancing performance (Levac et al., 2010). According to Arksey and O'Malley (2005), a scoping review serves four common research purposes: examining the extent, range, and nature of research activity; determining the value of undertaking a full systematic review; summarizing and disseminating research findings; and identifying research gaps in the existing literature. To achieve these purposes, Arksey and O'Malley (2005) suggested that the research questions in a scoping review serve as a general guide, rather than a rigid, narrow direction for regulating studies collection and selections. This practice therefore requires iterative processes of literature search and encourages the flexible use and identification of keywords during the search. As microlearning is still in its early stages in terms of adoption, implementation, and research, the aims of a scoping review meets the purpose of the present study: to obtain a general sense of current microlearning as a research area and to identify gaps for future research in the field.

Arksey and O'Malley's (2005) methodological framework lays out five stages for conducting a scoping review—Stage 1: Identifying the research question; Stage 2: Identifying relevant studies; Stage 3: Study selection; Stage 4: Charting the data; Stage 5: Collating, summarizing, and reporting the results. As Arksey and O'Malley (2005) emphasized, the process of a scoping review should not be linear, but iterative and flexible, to ensure that a comprehensive review of the literature is achieved. In the following section, we will report the processes of Stages 1–4 of this study, followed by Results and Discussions sections which will report the results from Stage 5 of the study.

Research questions

(1) What are the current trends of implementation and research on microlearning?
(2) What are the effects of microlearning on enhancing learner performance?

Identifying relevant studies

The following search queries were used to identify relevant studies for this scoping review. Key words used in the queries are the following terms: *microlearning*; *micro-learning*; *microlearning* AND *performance*; *bite size learning*; *bite-sized learning*; *microlearning* AND *impact*; *microlearning in the workplace*; *microlearning* AND *adult learning*; *microlearning* AND *adult education*. The initial search results indicated that including the terms *just-in-time training* and *text messaging* would also be valuable in the analysis; therefore, both terms were subsequently added to the literature searches. Additionally, terms such as *short training*, *short video training*, *knowledge nuggets*, *small learning*, and *text message learning* were also added into the list of terms for searching the literature within the iterative literature databases. Searchable databases included ERIC, PsycInfo, PsyARTICLES, Academic Search Complete, EBSCO MegaFILE, E-Journals, Business Source Complete, MasterFILE, Premier, CINAHL Complete, and Professional Development Collection.

Resources listed in the identified studies were also reviewed for potential suitable inclusion for the scoping review.

Stage 2: study selection

Initial database searches resulted in 423 studies and articles. The results were refined by limiting the initial results to peer reviewed articles only, published from 2009 to 2020, and with publication language in English only. Once these additional filters were applied, 63 studies and articles were left for further detailed review of abstracts for consideration.

In the review of the abstracts for further selection, the following inclusion and exclusion criteria were applied.

Inclusion

- Includes use of microlearning for purpose of educating/training/teaching;
- Traditional training and learning programs involve forms of instructor-led, online courses, or a blend of each modality;
- Includes adult learning environments;
- Includes higher education and professional studies;
- Workplace context.

Exclusion

- Excludes trade and industry articles on microlearning due to general nature and lack of data information from studies;
- Excludes articles greater than ten years old ~ circa 2009;
- Excludes studies published in a language other than English;
- Excludes learning and educational environments for K-8 classrooms.

After reviewing the abstracts from the subset of 63 filtered results, 23 articles met the inclusion/exclusion criteria for the scoping review on the themes of microlearning employed as training in the workplace. Those 23 articles were downloaded for further content review and included for the scoping study. During this initial content review, 10 studies were further excluded for not meeting the specified Inclusion/Exclusion Criteria. As a result, 13 studies were included in the final review (see Fig. 1).

Stage 3: charting the data

Following Arksey and O'Malley (2005) methodology framework, "a 'narrative review' or 'descriptive analytical' method is used to extract contextual or process-oriented information from each study" for the final 13 studies (Levac et al., 2010, p. 3). The extracted information is categorized in a Microsoft Excel spreadsheet for ease of viewing and provides a comprehensive overview of potential common themes from the studies. Information in the spreadsheet includes authors, year, short title, ML Category, discipline, participants, sample size, duration, measures, performance, acceptance, and technology used. All 13 articles were reviewed in detail pertaining to trends when employing microlearning as training in the workplace (see Table 1).

In the following, we will summarize and report the results.

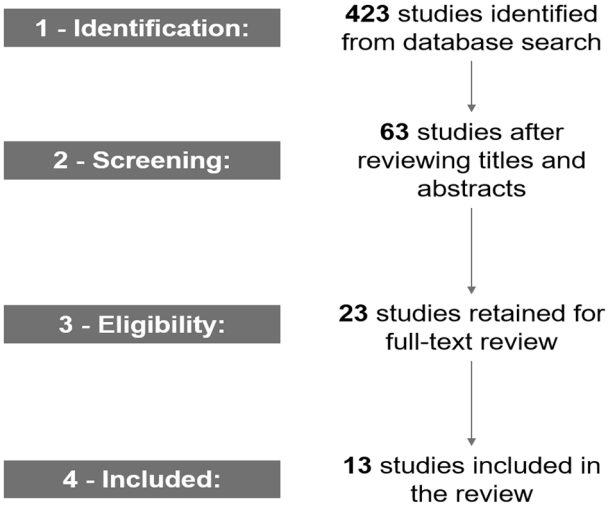

Fig. 1 Identification of relevant studies process

Results

Terms and definition

In researching the use of microlearning as a learning strategy, two main terms were found that define microlearning: *microlearning* and *just-in-time learning*. Six studies in this scoping review use the term *microlearning*. A common trait in microlearning is the brevity of the learning typically focused on a single topic or objective (De Gagne et al., 2019; Gross et al., 2019; Hesse et al., 2019; Pascual et al., 2018). Microlearning may also be delivered in a variety of formats, such as videos, online courses, assessments, and in-line application help text (Orwoll et al., 2017), to support the shorter duration and focus on a single concept of knowledge.

Three studies used the term *just-in-time learning* with an additional three studies using *SMS* (short messaging service) as a method of just-in-time learning. Just-in-time learning adds the criteria of presenting the microlearning at the time of need for the learners to address a knowledge or skill gap (Branzetti et al., 2017; Cheng et al., 2017; McIntosh et al., 2009). SMS is a specific application of just-in-time learning in which information or single questions and answers are sent to the learners using a mobile device (Chuang & Tsao, 2012; Han et al., 2015; Sichani et al., 2018). Four studies did not include a definition or clear description of the term microlearning or just-in-time learning.

While many studies in this review did not provide a clear definition for their microlearning intervention, the ones that defined the method varied in their definition of the focus of the instructional purposes and functions. These differences mainly fell into two main aspects: time and size. For example, the time-focused (duration or timing) definitions described microlearning or just-in-time learning by saying that "extremely focused, well-designed JIT interventions are brief" (Branzetti et al., 2017, p. 882). They also described microlearning as "timely and focused education" (Cheng et al., 2017) or that it "provides learners with critical information that is available for their immediate use" (Mcintosh et al., 2009). Likewise, the size-focused definition described microlearning as "smaller episodes, skill elements," or "knowledge nuggets" (Gross et al., 2019). On the other hand, Hesse

Table 1 Data chart of the studies

Authors (Year)	Title	Category	Discipline	Participants	Sample size	Duration	Measures	Performance	Acceptance	Technology
Branzetti et al. (2017)	Randomised controlled trial to assess the effect of a JIT training on procedural performance	JIT training	Emergency medicine	Physicians	25	6 months	Technical skills ratings, global performance ratings, time to TVP placement, number of critical omissions, System Usability Scale scores	JIT group significantly outperformed the control group in the technical checklist score (23.44 vs. 11.45, $p < .001$, the global rating scale (4.54 vs. 2.27, $p < .001$, critical omissions (0.68 vs. 2.23, $p < .001$, no sig. diff. in procedural completion time (12.80 vs. 11.15 min, $p = .12$)	Excellent usability on System Usability Scale score of 88.4	• Portable device • Videos • Interactive checklist

Table 1 (continued)

Authors (Year)	Title	Category	Discipline	Participants	Sample size	Duration	Measures	Performance	Acceptance	Technology
Cheng et al. (2017)	Teaching splinting techniques using a just-in-time training instructional video	JIT training	Pediatric	Medical students	41	7 months	Standard 6point skills checklist, time for splinting preparation, time for completing a splint	JIT group performed significantly better than the control group on splint checklist (5.45 vs. 1.58, $p < .0001$), time for presplinting preparation (7.86 vs. .89, $p < .0001$), pass rates (73% vs. 0%, $p < .0001$). Time for completing a splint was not significantly different between the two conditions	Students deemed JIT as a potential method for optimizing learning procedural medical knowledge	• Instructional videos

Table 1 (continued)

Authors (Year)	Title	Category	Discipline	Participants	Sample size	Duration	Measures	Performance	Acceptance	Technology
Chuang and Tsao (2012)	Enhancing nursing students' medication knowledge	Flash lesson	Nursing	Nursing students	106	10 days	Medication knowledge scores (MKQ)	SMS intervention group showed significantly higher medication knowledge scores (MKQ) than the control group after 1, 2, and 3 weeks of intervention (Wald $\chi^2 = 9.37$, $p = .002$; Wald $\chi^2 = 10.97$, $p = .001$; Wald $\chi^2 = 7.93$, $p = .005$)	SMS intervention group reported an above-average satisfaction level with SMS intervention method	• SMS

Table 1 (continued)

Authors (Year)	Title	Category	Discipline	Participants	Sample size	Duration	Measures	Performance	Acceptance	Technology
Gross, et al. (2019)	Microlearning for patient safety: Crew resource management training in 15-min	Short lesson	Medical education	Medical students	120	15 min	Knowledge retention, perception of CRM tool	The example-based group scored significantly higher than did the lecture-based group in the retention of elements of CRM tool immediately after the intervention (examplebased group M = 2.40, lecture-based group M = 1.15; t = 7.2, df = 116.9, p < .001, Cohen's d = 1.30) as well as two weeks later (example-based group M = 1.87, lecture-based group M = 0.77; t = 4.54, df = 69.7, p < .001, Cohen's d = 1.00)	Both groups rated intervention (above 50%) as relevant for practice and realistic, and training content useful for daily routines	• Instructional videos • Simulation

Table 1 (continued)

Authors (Year)	Title	Category	Discipline	Participants	Sample size	Duration	Measures	Performance	Acceptance	Technology
Han et al. (2015)	A pilot randomized trial of textmessaging for symptom awareness and diabetes knowledge in adolescent s with Type 1 diabetes	Flash lesson	Medical care	Adolescents with Type 1 diabetes	30	3–4 months	Metabolic control	Trends toward improvement in life satisfaction, metabolic control, and decreased worries; improved communication	Text message response rates was around 80% indicating receptiveness of intervention methodology	• Text messaging • Web-based dashboard

Table 1 (continued)

Authors (Year)	Title	Category	Discipline	Participants	Sample size	Duration	Measures	Performance	Acceptance	Technology
Hesse et al. (2019)	Micro-learning courses are effective at increasing the feelings of confidence and accuracy in the work of dairy personnel	Short lesson	Agriculture (Dairy farming)	Farm owners, employee, veterinarians	117	NA	64 participants completed the self-evaluation survey. In selfe-valuating confidence of performing required task, 78 percent of the responses indicated absolutely on a 3-pont scale (Absolutely, Undecided, and Not really)	High percentage accessed relevant background information and SOP section 80% convinced they could perform task more accurately. 77% felt more confident in correct task performance	Overall, 89% of participants rated all three courses were rated as very good or good	• Online courses • Videos

Table 1 (continued)

Authors (Year)	Title	Category	Discipline	Participants	Sample size	Duration	Measures	Performance	Acceptance	Technology
McIntosh et al. (2009)	Stabilization and treatment of dental avulsions and fractures by emergency physicians using justin-time training	JIT training	Dental	Emergency physicians	25	17.8 min	• Preference of procedures • Time to complete each splinting technique • Preferred splinting procedure	To assess time to complete each of the three splinting techniques and two bandaging techniques, method preferred by the physician in each of the techniques, and the reasons for that preference. Results suggest that emergency physicians showed a higher rate of procedural success after a single Justin-Time training in using the bondable reinforcement ribbon technique	• Recommending JIT video training as an instructional aid, rather than the main or only instruction • Effective for upto-date infrequently performed procedures training	• Demonstration videos • Flip-chart instructional manual

Table 1 (continued)

Authors (Year)	Title	Category	Discipline	Participants	Sample size	Duration	Measures	Performance	Acceptance	Technology
Orwoll et al. (2017)	Gamification and Microlearning for Engagement With Quality Improvement (GAMEQI): a bundled digital intervention for the prevention of central line–associated bloodstream infection	Short lesson	Medical care	Nurses	105	12 months	• Selfassessment • Central line– associated bloodstream infection (CLABSI) rate	CLABSI intervention group had 48% decline ($p=.03$) in CLABSI as compared to previous year rates while the control group did not change significantly	Another 10 + microlearning videos through the same social collaboration system were created and deployed within 1 year after the study	• Selfassessment application • In-line explanations • On-demand demonstration videos

Table 1 (continued)

Authors (Year)	Title	Category	Discipline	Participants	Sample size	Duration	Measures	Performance	Acceptance	Technology
Pascual et al. (2018)	Evaluating the Impact of personalized stroke management tool kits on patient experience and stroke recovery	JIT training	Medical care	Patients/caregive rs receiving poststroke education	7	1.5 weeks	N/A. Data is in the form of phone interviews and preference on type of materials in the recovery tool kits	4.5 out of 5 rating with 5 being very confident in how toolkits improved confidence about stroke recovery	Highly positive response from patients and caregivers	• Flashcards • Personalized stroke cheat sheets
Sawarynski and Baxa (2019)	Utilization of an online module bank for a research training curriculum: development, implementation, evolution, evaluation, and lessons learned	JIT training	Medical education (research)	Medical students	409	1 year	Student usage/access of the instructional materials	The number of students who (re)viewed the content materials increased from 10% of the student body (regular content modules) to 70% of the students (JIT content modules) in a "above and beyond" course requirements manner	Module combination students most preferred was short animation style modules	• E-learning courses • Videos

Table 1 (continued)

Authors (Year)	Title	Category	Discipline	Participants	Sample size	Duration	Measures	Performance	Acceptance	Technology
Sichani et al. (2018)	The effect of distance learning via SMS on academic achievement and satisfaction of medical students	Flash lesson	Medical education	Medical students	47	Two chapters	Content knowledge, satisfactory ratings	Significant differences in posttest and delayed test between SMS and lecture conditions ($p < .05$, $t = 2.480$) and ($p < .05$, $t = 2.24$)	78.72% of the students were not satisfactory with the SMS learning method	• Text messaging (SMS)
Simons et al. (2015)	Microlearning mApp raises health competence: hybrid service design	Short lesson	Health care education	Workers from three employers (Municipality, Advocacy, Care Provider)	86	10 months	Self-assessment of healthy behaviors	Increased user health selfmanagement competence; stable pattern of improved health awareness, motivation, and behaviors	Relatively high utilization rates of health quiz and course completions: indication of perceived usefulness	• Mobile app • Quiz • Blended learning • Digital flashcards

Table 1 (continued)

Authors (Year)	Title	Category	Discipline	Participants	Sample size	Duration	Measures	Performance	Acceptance	Technology
Yoo et al. (2018)	CloudBased implementation of new frontline clinical workflows: standardizing practice at scale to improve patient safety	Short lesson	Medical care	Frontline teams	N/A	3 weeks	Number of checklists being completed	A 70% increase in colorectal cancer screenings 1 year after the intervention; 70% increase in referrals to the Behavioral Health Pain Management Program; improved opioid safety, utilization of behavioral support resources for patients with chronic opioid use	N/A	• Cloudbased application • Checklists • Videos

et al. (2019) provided a more complete definition, stating that "microlearning refers to short training or e-learning units that impart knowledge within small fractions with a specific goal" (p. 9506). In review of how these researchers defined this emerging instructional approach, we offer a synthesized definition of microlearning as an instructional mode that targets at a discrete, highly focused topic or skill, provides small amounts of instruction that can be consumed in a short period of time and may be for immediate use. Furthermore, in addition to sharing the attributes of microlearning, JIT microlearning can be defined more precisely by its characteristics of being learner-driven and a timely provision of the knowledge need.

Trends and patterns based on data extracted in the Microsoft Excel spreadsheet and detailed reviews are discussed in the following section.

Categories of microlearning

The microlearning formats used throughout the 13 reviewed studies can be classified into three categories: short lesson, just-in-time (JIT) lesson, and flash lesson.

Short lesson

This format was one of the most common microlearning formats used (5 studies, 38%) among the studies included in this research. Short lessons are similar to traditional online course formats but have short durations of 5–10 min. The modalities for short lessons include video or eLearning courses. Short lessons are mostly used in demonstrating procedures and processes in which learners need to access information visually on the tasks to perform.

JIT This format was also popular in ML instruction (5 studies, 38%). JIT lessons are defined by the nature of the learner's training need and when it should be met. This category of microlearning lessons contains short, highly contextualized and customized content that also includes a time contingency. JIT microlearning is user-driven, which means the microlearning lessons are taken when the participants need the information to perform a task immediately. The modality for the JIT format has a wider range for customization to the participant's context or situation. A few JIT examples include flashcards on health practices and information for recovering stroke patients (Pascual et al., 2018) as well as demonstration videos for emergency physicians needing a refresher on infrequent procedures (Branzetti et al., 2017). The flexibility and variety of JIT training makes it suitable for use across many disciplines, industries, and situations. More importantly, it allows learners to be in control of their learning which impacts motivation and engagement.

Flash lessons

Three (24%) of the studies used a flash lesson format. These microlearning lessons use text messaging formats exclusively and are deployed by mobile technology. Content is delivered in the form of questions and answers and requires action from the participants. Tasks may include selecting from pre-set answers to questions or researching websites or course materials for further information. (Chuang & Tsao, 2012; Han et al., 2015; Sichani et al., 2018) (see Table 2).

Table 2 Percentage of studies for each category of microlearning

Category of microlearning	Percentage of studies (%)
Short lesson	38
JIT	38
Flash lesson	24

Instructional strategies employed

A range of unique and traditional instructional strategies are employed within each microlearning training category.

Demonstration

Demonstration videos have been a common instructional strategy used in short lession microlearning trainings, as shown in the example of Gross et al.'s (2019) crew resource management training (CRM) study. Prior to performing the CRM process in a simulation scenario, the medical students in the experimental group viewed a CRM video, in which the steps were demonstrated and the importance of the steps were explained for each role involved.

Gamification

Gamification is also a common instructional strategy that has been used in microlearning. For example, in the prevention of Central Line–Associated Bloodstream Infection (CLABSI) project (Orwoll et al., 2017), the nurses in high infection units accessed microlearning included explanations and pop-up on-demand video demonstrations to work on reducing central line-associated bloodstream infections, or CLABSI. Gamification occurred in the construct of a contest among nursing units with monthly status updates at staff meetings and rating boards that encouraged both participation and lower infection rates (Orwoll et al., 2017). The results showed that the CLABSI intervention group had a 48% decline ($p = .03$) in CLABSI as compared to the previous year's rates while the control group did not change significantly.

Questions and answers

Using text messages in the form of questions and answers has also been seen in microlearning. This instructional strategy can be used to deliver informational content in a simple Q&A format or require the learners to respond to the questions. Two studies in this review utilized this strategy (Han et al., 2015; Sichani et al., 2018). In Han et al.'s (2015) study with adolescents with type 1 diabetes, the participants were required to send answers to the texted questions. Answers were constrained to one letter responses, meaning the choices were yes/no or true/false, to encourage engagement with the adolescent demographic (Han et al., 2015). In Sichani et al.'s (2018) study, stand-alone text messaging delivered to the medical students' mobile phones was used as the main

learning approach. The medical students were expected to research further the answers to questions on kidney tumors.

Effects of microlearning on learning outcomes

The most direct and apparent effect of microlearning training was on the performance in completing a specified task or process or increase in area of knowledge. Other areas of microlearning impact measured by this study included confidence, self-perception, and utilization rate of the knowledge or skills under study. Eight of the 13 studies (62%) reported positive results on task-based performance objectives. Task-based performance assessments include knowledge acquisition and skills acquisition attainment.

Knowledge acquisition

Five of these eight studies (63%) measured the students' knowledge acquisition (Branzetti et al., 2017; Chuang & Tsao, 2012; Gross et al., 2019; Han et al., 2015; Sichani et al., 2018). All of the microlearning intervention groups in these studies had positive knowledge assessment scores. When compared with the respective control groups, the scores of the microlearning groups were generally higher than the control group's scores (Branzetti et al., 2017; Chuang & Tsao, 2012; Han et al., 2015; Gross et al., 2019; Sichani et al., 2018). For example, in Branzetti et al.'s (2017) study, the primary performance outcome was measured with a technical skills checklist score for both the control group and the intervention group. At baseline assessment, the control group scored 9.17 and the intervention group scored 11.60 (Branzetti et al., 2017, p. 887). At the final assessment, the intervention group scored 23.44, which was significantly higher than the control group's score of 11.45 ($p < .001$, Cohen's $d = 4.64$) (Branzetti et al., 2017). Moreover, quality of life could be improved by acquisition of necessary knowledge that is mediated by an effective instructional approach, in this case, microlearning. In Han et al.'s (2015) study of adolescents with diabetes, microlearning was employed as an instructional approach to increase the participants' awareness of the symptoms and knowledge about diabetes. The participants were randomly assigned into three groups: receiving questions/answers about symptoms only (group S); receiving questions/answers about symptoms, plus related medical knowledge (group SK); and not receiving any information (control group). No significant differences were found among the three groups in the measures of metabolic control (Glycosylated hemoglobin, HbA1c) after the invention. However, the SK group significantly reduced their worries about diabetes (diff. = − 10.42, $p < .001$) and the S group lessened their worries, but not significantly (diff. = − 0.1, $p = .482$). However, the control group's worries about diabetes increased (diff. = 4.28, $p = .96$). In comparison of the three groups' perceptions of impact on diabetes, significant differences were found between the control group and SK group (diff. = − 12.577, $p = .003$) as well as the S group and SK group (diff. = − 8.78, $p = .022$). Thus, Han et al. (2015) concluded that using mobile SMS texts to deliver microlearning to adolescent diabetes patients enhanced their quality of life by helping them to be more knowledgeable about the disease and its symptoms.

In this review, three studies (38%) also assessed the students' retention of the knowledge under study. The results indicated that the microlearning trainings helped the participants retain their learning over a longer period of time in comparison to the control groups (Chuang & Tsao, 2012; Gross et al., 2019; Sichani et al., 2018). For example, posttests and delayed tests (administered one month after the posttest) were used to measure knowledge

retention in Sichani et al.'s (2018) study. Significant differences were found in both posttests and delayed tests between SMS and lecture conditions (posttest, $t = 2.480$, $p < .05$; delayed test, $t = 2.24$; $p < .05$, respectively). Similarly improved results were reported for Gross et al.'s (2019) study in that "the example group remembered significantly more elements of the CRM tool that were presented in the videos than the lecture group" in terms of knowledge retention (p. 13). Particularly, in Chuang and Tsao's (2012) study, the intervention group that used flash lessons with text messaging (SMS) showed significantly higher medication knowledge scores (MKQ) than the control group after one, two, and three weeks of intervention (Wald $\chi^2 = 9.37$, $p = .002$; Wald $\chi^2 = 10.97$, $p = .001$; Wald $\chi^2 = 7.93$, $p = .005$, respectively).

Skills acquisition attainment

Skills acquisition attainment assessments were conducted in some of the studies (e.g. Branzetti et al., 2017; Cheng et al., 2017; Gross et al., 2019; McIntosh et al., 2009; Orwoll et al., 2017). Specifically, Branzetti et al. (2017) assessed the students' procedural skill decay in a simulation-based scenario and found that the microlearning group significantly outperformed the control group in checklist scores (23.44 vs. 11.45, $p < .001$), the global rating scale (4.54 vs. 2.27, $p < .001$), and the critical omissions (0.68 vs. 2.23, $p < .001$). However, no significant difference was found in procedural completion time between the two groups (12.80 vs. 11.15 min, $p = .12$). Cheng et al. (2017) observed similar results in that the JIT group performed significantly better than the control group on splint checklist scores (5.45 vs. 1.58, $p < .0001$), time for pre-splinting preparation (7.86 vs. 0.89, $p < .0001$), as well as pass rates (73% vs. 0%, $p < .0001$); however, time for completing a splint was not significantly different between the two conditions. Gross et al. (2019) reported in their study on how microlearning videos for training medical students on use of the CRM tool were employed for both the experimental group and control group. Example-based video instruction was used for the experimental group, while lecture-based video instruction was used for the control group. Both groups exhibited retention of most of the behaviors and actions from the video content. However, the example-based group scored significantly higher than the lecture-based group in the retention of elements of CRM tool immediately after the intervention (example-based group $M = 2.40$, lecture-based group $M = 1.15$; $t = 7.2$, $df = 116.9$, $p < .001$, Cohen's $d = 1.30$) and 2 weeks later (example-based group $M = 1.87$, lecture-based group $M = 0.77$; $t = 4.54$, $df = 69.7$, $p < .001$, Cohen's $d = 1.00$). Also, by providing the nurses access to the microlearning units about reducing central line-associated bloodstream infections (CLABSI), the CLABSI infection rate was down to 48%, reduced from previous years data (Orwoll et al., 2017).

Confidence

Hesse et al.'s (2019) study on dairy farms looked at perceived ability and confidence of dairy workers after they took three microlearning online courses on specific dairy tasks and procedures. Overall, 80% of participants were convinced they could perform the task more accurately after completing the course, and 77% felt more confident in performing the task correctly after taking the course (Hesse et al., 2019). Also, Pascual et al.'s (2018) study provided details on the use of microlearning for stroke recovery outpatients to learn the effects of different toolkits on patients and their caregivers during stroke recovery. The

results were encouraging and indicated positive effects on confidence levels and more frequent use of the toolkits for those in stroke recovery.

Similarly, Simons et al.'s (2015) study on the use of a mobile Health Quiz App on self-health competence showed an increased user health self-management competence and confidence. Furthermore, the data also showed a stable pattern of improved health awareness, motivation, and behaviors among the users ten months after program intervention. There were also relatively high utilization rates for the mHealth Health Quiz App and course completions which may indicate perceived usefulness (Simons et al., 2015). Moreover, Han et al.'s (2015) study on adolescents with type 1 diabetes demonstrated the benefits of receiving daily text messages (flash lessons) on improving life satisfaction and metabolic control of the diabetic participants.

Utilization and engagement

Sawarynski and Baxa's (2019) study focused on how medical students used microlearning modules to complete a self-directed learning program as a requirement of their medical education. The microlearning modules were converted from the existing learning modules to short mini-modules and realigned with the corresponding in-class topic presentation. The results indicated a high percentage of students used the shortened microlearning modules above and beyond course requirements. Similarly, the rewatching of the modules after the assignment date in a JIT scenario was observed in Han et al.'s (2015) study. High utilization (or repeated watching) of the online modules demonstrates a level of engagement that went further than what the students were required for the program.

Acceptance of microlearning methodology

With the exception of three studies, a high level of acceptance of microlearning by the learners is apparent. Feedback on the use of microlearning was conducted using various methods including surveys, focus groups, and interviews among those studied in this review. The results indicated that when used within a larger learning program as one of the learning components, microlearning was perceived as easy to use, relevant, realistic, and favorable. Additionally, microlearning tended to receive above average satisfaction ratings and resulted in high utilization rates and high response rates. In Pascual et al.'s (2018) stroke recovery study, responses received from the patients and caregivers were overwhelmingly positive for the toolkits that included microlearning components of flashcards and cheat sheets. For Gross et al.'s (2019) study on crew resource management training, the microlearning group rated the intervention as relevant for practice (above 50%), realistic (above 50%), and useful for daily routines (above 50%). In Orwoll et al.'s (2017) microlearning lessons for reducing CLABSI infections, they found that infection rates were lower in the year following the conclusion of the study. As a result, the participating hospital created and deployed over ten additional microlearning videos through the same social collaboration system. The success of CLABSI may be attributed to its gamification design, which included several elements. The CLABSI app is a self-assessment application in the form of a checklist resembling the institutional CLABSI prevention nursing care tool that participants completed at the end of their shift (Orwoll et al., 2017). Microlearning videos were integrated within the application and included in-line explanations of each CLABSI prevention bundle element and pop-up on-demand video demonstrations (Orwoll et al., 2017). Participants could view individual performance and their overall unit performance

compared to the aggregate performance of all units (Orwoll et al., 2017). The CLABSI app was implemented along with a gamification engine for the creation of teams and competitions for different shifts and nursing units. Points were awarded for each self-assessment completed by the end of the shift, and rewards included nominal value prizes such as food, gift cards, and raffle tickets (Orwoll et al., 2017). In addition, participants experienced intrinsic and extrinsic motivation with the ability to self-check individual progress and accuracy and compare those markers with the overall unit and across units. This infrastructure along with the learning elements in the CLABSI app created not only an enjoyable experiential learning model but also decreased the infection rates.

The only negative feedback on acceptance from the learners was found in Sichani et al.'s (2018) study that used text messaging flash lessons as the only standalone mode of learning format for the medical students. The students in the text messaging flash lessons learning group had an above average dissatisfaction level with this learning method, as shown in the survey results (Sichani et al., 2018). The lack of additional supporting learning resources, such as feedback or additional instruction, may have reduced the students' motivation to further their studies. Additionally, because the medical students were accustomed to traditional lecture classroom learning, a drastic shift to a solely text-driven learning method might have appeared abrupt, unsettling the learners (Sichani et al., 2018) (see Table 3).

Technology employed

Lessons creation, delivery and management

The technology used among the 13 studies ranged from low technology solutions to complex multi-user systems. The platforms used to access the microlearning trainings included desktops or laptop computers, mobile devices (such as phones and tablets), and specified portable devices for clinical environment. Two of the studies (15%) used desktops or laptop computers for the microlearning trainings, given the participants engaged in the trainings in a workplace environment (Orwoll et al., 2017; Yoo et al., 2018). Three studies (23%) designed the microlearning modules to use mobile phones primarily (Chuang & Tsao, 2012; Han et al., 2015; Sichani et al., 2018), as text messaging flash lessons were the main microlearning format used in these three studies. Another three studies (23%) indicated mobile devices in platform usage but did not specify what kind of mobile devices were used (Hesse et al., 2019; Sawarynski & Baxa, 2019; Simons et al., 2015). One study (8%) used a portable device specifically for use in emergency department clinical environments (Branzetti et al., 2017). The remainder of the studies did not report the platform employed or did not use technology.

Table 3 Comparing and contrasting the effects of microlearning in measuring types of outcomes

Effects of microlearning on learning outcomes	Percentage of studies (%)
Knowledge acquisition	63
Retention of knowledge	38
Skills acquisition attainment	63
Learner confidence level	31
Acceptance of microlearning methodology	77

In terms of microlearning categories, flash lessons primarily used text messaging formats and were deployed by mobile technology. This instruction required the participants to use their own personal mobile devices to receive content information and send responses. The modality for the JIT formats had a wider range of options for customization to the participant's context or situation. The technology required was determined by how the JIT was both created and delivered. For the Pascual et al.'s (2018) toolkit training for stroke recovery patients, the JIT components included traditional flashcards with general information on stroke or maintaining physical and mental well-being. The technology requirements for the patients were minimal; participants were not required to view and read the flash cards via technology. On the contrary, in Branzetti et al.'s (2017) study on procedural skill decay in hospital emergency departments, JIT trainings were developed for viewing on mobile devices that were only appropriate for use in emergency department clinical environments. Technology requirements for both JIT training development and execution in that environment would be much more complex than traditional flashcards. For the short lesson microlearning, the course was similar to traditional online course formats but had short durations of 5–10 min.

Among the studies reviewed, the modality for delivering content included video or eLearning courses. The videos or eLearning courses were viewable from any device such as desktops or mobile devices (Hesse et al., 2019). The content materials were developed with hand-held video devices or eLearning course development software to either create the video output or convert existing slides into video or eLearning outputs (Cheng et al., 2017; Sawarynski & Baxa, 2019). Simons et al.'s (2015) study was the only study (7%) that used a mobile application designed for mobile devices. The mobile application focused on self-competence in health maintenance and was designed as a robust multi-tiered intervention program that also included a mobile device Health Quiz accessible through a mobile application.

Media for content delivery

The media for the microlearning training included a wide variety of formats. Videos were used in seven of the studies (54%), with three (43%) using the videos along with skills checklists (Branzetti et al., 2017; Cheng et al., 2017; Orwoll et al., 2017). Text messaging in the form of questions were utilized in three studies (23%), with two (67%) of the microlearning interventions requiring a text message response from the participants (Chuang & Tsao, 2012; Han et al., 2015; Sichani et al., 2018). Traditional forms of eLearning (or online courses) and online content were incorporated in three studies (21%) (Hesse et al., 2019; Orwoll et al., 2017; Sawarynski & Baxa, 2019), while paper formats included flashcards and cheat sheets of information in Pascual et al.'s (2018) study on toolkits for stroke recovery patients.

Research design

Eight of the 13 studies (62%) utilized control groups to compare performance results with the microlearning intervention group. In terms of data collection, two studies (15%) compared the scores from the baseline or pretests with the scores of posttests to determine results (Branzetti et al., 2017; Han et al., 2015). Three studies (23%) also included the addition of a knowledge retention posttest to the use of baseline or pretests with posttests

to gauge longer term knowledge acquisition (Chuang & Tsao, 2012; Gross et al., 2019; Sichani et al., 2018).

Target outcomes measured

Of the seven studies (54%) that used assessment, three (43%) were specific to the tasks or procedures taught (Branzetti et al., 2017; Cheng et al., 2017; McIntosh et al., 2009). The remaining four (57%) focused on participant self-evaluation, self-perception, or microlearning utilization frequency (Hesse et al., 2019; Pascual et al., 2018; Sawarynski & Baxa, 2019; Simons et al., 2015).

Assessment formats and data sources

Questionnaires, tests, and demonstrations were the most common formats of assessments used in the studies reviewed. The former two formats account for 54% of these studies (seven studies). The questionnaires or tests ranged from knowledge testing to quality-of-life evaluation (e.g. Gross et al., 2019; Han et al., 2015). On the other hand, demonstration assessments required the participants to perform the target task or procedure, which was assessed by independent reviewers using a skills checklist. Three of the studies used this type of assessment (23%) (Branzetti et al., 2017; Cheng et al., 2017; McIntosh et al., 2009). Furthermore, historical data and actual utilization rates were also used in some of the studies as measurements of outcomes. Two studies (15%) compared historical data to the participant performance data, collected during the microlearning, to assess the impact of the intervention on their learning and job performance (Orwoll et al., 2017; Yoo et al., 2018). Lastly, one study (8%) used frequency of access to the microlearning trainings and utilization rates to assess participants' engagement (Sawarynski & Baxa, 2019).

Disciplines

The majority of the studies examined in this scoping review came from medical and healthcare related fields. Eight of the 13 studies (62%) were conducted in medical fields, among which three (38%) involved medical professionals such as physicians or nurses (Branzetti et al., 2017; Orwoll et al., 2017; Yoo et al., 2018). The remaining five studies (62%) involved medical or nursing students (Cheng et al., 2017; Chuang & Tsao, 2012; Gross et al., 2019; Sawarynski & Baxa, 2019; Sichani et al., 2018). The healthcare fields had the second most studies, with three studies (23%) covering the areas of diabetes management in adolescents, self-health competencies for the aged population, and toolkits for stroke recovery patients (Han et al., 2015; Pascual et al., 2018; Simons et al., 2015). The remaining two studies (15%) were from post medical school dentistry training (McIntosh et al., 2009) and dairy farming (Hesse et al., 2019).

Learner population

Collectively, all the studies involved a wide range of participants in the demographics of age, gender, occupation, and location. However, they were somewhat homogenous in types of industries (i.e., medical and healthcare). In terms of learner populations, the studies ranged from the medical and healthcare fields to dairy farms workers, to an older demographic concerned with health self-maintenance, and to adolescents with type 1 diabetes.

An encouraging observation is in the use of microlearning across a wide range of learner populations in terms of age groups, educational levels, and disciplines. Because the sample size of this scoping study was small, the inclusion of older and younger learners can help enrich our understanding on the effects of microlearning on different learner populations and in different learning contexts. The variety in some way speaks to the wide applicability of this learning modality.

Discussion

While microlearning is a recent phenomenon in the educational institutes and training industries, "no standardized concepts, or applications" are yet established for the development or uses within those settings (De Gagne et al., 2019, p. 2). Based on the studies in this review, some obvious commonalities among these microlearning trainings include short duration, a direct and concise presentation of information, ease of use and ease of accessibility, user-driven content, and a focus on a single topic or concept. However, variations also exist in terms of lesson categories (short lesson, flash lesson, and JIT), instructional strategies, media for content delivery, platforms for lesson delivery and management, as well as technology. In the following section, we will discuss some of the notable trends and their instructional implications.

Supplemental in nature

An observation in this scoping study showed that most microlearning implementations were used as supplemental rather than the primary or only learning component in the facilitation of student learning. More interestingly, the programs that used microlearning as the only learning format seemed to receive a lower user satisfaction level than the ones that utilized microlearning as part of a larger learning program. This finding may be because larger learning programs provide more resources, support, and feedback for a fuller learning experience than the programs in which the microlearning component was the only learning mode. Another possible explanation may be that the briefness of microlearning inevitably limited the lessons to small and discrete topics. This characteristic excludes microlearning from being able to present topics that are structural or systemic in nature. As a result, students may have felt their knowledge was fragmented or had difficulty integrating the what they learned. Thus, it may be more instructionally beneficial for microlearning to play a supplemental role in supporting larger learning infrastructures or programs. Traditional lectures, seminars, workshops, or self-paced courses could fulfill the function of helping students construct the conceptual framework of the subject matter. Microlearning, on the other hand, could be used to provide a training scaffolding for specific learning needs, such as informational lessons, just-in-time refreshers, or opportunities for practice (e.g., flashcards).

Effective in supporting task/knowledge-based learning

Not surprisingly, the most commonly measured outcome from using microlearning to enhance learners' performance was task performance proficiency or knowledge acquisition. In all the studies reviewed, the results indicated measurable improvements. This review showed that in general, these microlearning lessons helped the students perform

tasks more accurately and reduce error rates. As for the knowledge-based outcomes, microlearning resulted in higher scores than traditional instructional approaches. In some cases, the students who received microlearning instruction retained the information and learned more than their counterparts after the learning intervention.

The briefness of microlearning again may have been the underlying factor for these positive effects of microlearning on the student performance. Though some researchers have argued otherwise (e.g., Bradbury, 2016), many researchers have contended that the human attention span is somewhat limited (approximately less than 10–15 min) (e.g., Davis, 1993; Hartley & Davies, 1978; McKeachie & Sviinicki, 2006). Kulhavy et al. (1986) argued that attention is necessary for a given piece of information to be processed and remembered. Therefore, when the lessons are short (5–10 min), the students are more likely to be focused during the entire lesson. As a result, the learning effectiveness is likely to increase. Moreover, since microlearning lessons are based on a single topic, the students' learning of that topic would be more concentrated and focused.

Effective in confidence building

Increasing students' confidence in their performance through microlearning was shown in the positive effects on the students' perceived confidence (Hesse et al., 2019; Pascual et al., 2018), sense of improved quality of life, and fewer worries about their health conditions (Han et al., 2015). These outcomes are in some ways less tangible than task-based metrics or knowledge-based assessments. However, their impacts create a level of self-awareness and attitude that relates to important metrics, namely engagement and motivation. We also noticed that the students' response rates or utilization rates (the techniques or toolkit the microlearning lessons were teaching) were also generally high in these respective studies, which may reflect the positive effects translated from the successful learning of the topics. These potential effects of microlearning on learners' performance merits further research.

High acceptance of microlearning

Another observation from this scoping study was the high acceptance of microlearning by the students. The brief nature of microlearning may explain this result to some degree. We suspected that an implicit underlying variable may be at work here. As current social media culture and internet user habits have influenced people's informal learning behaviors, short and quick informational pieces from social media fill people's daily lives. Viewing YouTube-style videos to learn how to accomplish a task has become a predominate way of informal learning for many people. These information-seeking and consuming behaviors can arguably create a culture in which learners pull the knowledge and information they need when they need it, which may unconsciously influence preferences of learning mode. Microlearning is in line with this new informal learning culture, and perhaps partially explains the high acceptance rates of the students. Therefore, if the format of microlearning is in tune with informal learning behaviors and the information-seeking/consuming culture, then instructional design researchers, educators and trainers may need to further explore the benefits of microlearning. This instructional approach is able to take full advantage of informal learning cultures and translate it to the contexts of workplace training or formal academic learning. Also, an in-depth understanding of what categories of microlearning (short lessons, flash lessons, or JIT) are suitable for certain types of knowledge or

skill acquisition (e.g., informational or procedural knowledge) will be needed for optimal instructional design of microlearning instruction.

Underwhelming empirical studies in non-medical fields

During our literature databases search and studies selection process, we noticed that the number of microlearning related articles was fairly low, which indicates that research of the topic is still in its infancy stage. Furthermore, among the articles included in this review, an extremely high percentage were conducted in medical and healthcare contexts. This disproportionally high percentage of empirical healthcare microlearning studies indicates an urgent need for more non-medical/healthcare empirical studies of microlearning to help enrich our understanding of this instructional approach. This finding is important because each discipline has its own unique nature of domain knowledge, types of reasoning skills (e.g., diagnostic reasoning in medical education, argumentation in law, or inductive reasoning in nature science), and culture of the discipline or industry. The study of a pedagogy or learning mode in only a limited number of contexts may skew our understanding of its general effects as well as context-dependent effects on student learning. Thus, more non-medical/healthcare microlearning empirical studies are needed to provide a more comprehensive picture of microlearning as an instructional methodology.

Instructional design implications

Reports on the implementations of the studies reviewed in this paper suggested that, though these microlearning instructions shared common features (such as short duration or learner-driven content), the three categories of microlearning also have their own strengths that better afford different learning needs (see Table 4).

Instructional purpose

In the composition of their instruction, short lessons function more as mini-lessons that are suitable for supplemental learning by supporting the instruction within the full course. As a result, short lessons may deliver content information similar to regular courses or modules but at a much shorter length and in smaller amounts of information. JIT, as its name suggests, is designed to provide just-in-time learning needs (most likely for infrequently used skills or procedures), rather than functioning as a regular learning event. Flash lessons, on the other hand, serve well in helping students regulate their self-paced learning.

Types of learning

Because of their abbreviated durations, short lessons are not effective in microlearning instruction for learning that requires in-depth reasoning or comprehension. Informational or simple conceptual learning may be more suitable type of learning for the use of short lessons. Informational learning is defined in this context as an informal learning event in which the learners to receive specific information for a specific purpose (for example, new student orientation or drug abuse prevention workshops). As at least two studies (Branzetti et al., 2017; McIntosh et al, 2009) in this review concluded, JIT is especially effective for learning or refreshing infrequently used procedural skills. JIT is also effective in time management for the learner (e.g., physicians) as well as in reducing instructional cost (i.e.,

Table 4 Suitable instructional affordances for the three categories of microlearning

	Short lesson	JIT	Flash lesson
Instructional purpose	Supplemental to main course learning[l]	Provide just-in-time learning needs[a,b,g]	Directing selfpaced learning[c,e]
Suitable type of learning	Informational learning, conceptual learning, procedural knowledge learning[h]	Procedural knowledge/skills acquisition (especially for infrequently used procedures); refresher for previous learned skills[a,b,g]	Discrete factual knowledge retention[e]
Suitable format	Videos, animations, podcasts, web-based instruction[d,f,m]	Videos, job-aids, cheatsheets[b,i]	Text messages, flash (e)cards[c,e]
Instructional strategies could be incorporated	Short readings, examples and non-examples, images, multimedia presentations[d,f,h,l,m]	Demonstrations, images, videos, animations, audio instruction for directing practicing the skills[g,j]	Scheduled lessons delivery, concise messages[k]

The superscripted number indicates the study that supports the instructional affordance

[a]Branzetti et al. (2017)

[b]Cheng et al. (2017)

[c]Chuang and Tsao (2012)

[d]Gross et al. (2019)

[e]Han et al. (2015)

[f]Hesse et al. (2019)

[g]McIntosh et al. (2009)

[h]Orwoll et al. (2017)

[i]Pascual et al. (2018)

[j]Sawarynski and Baxa (2019)

[k]Sichani et al. (2018)

[l]Simons et al. (2015)

[m]Yoo et al. (2018)

no need to include it in regular instructional hours). Flash lessons are effective for pacing students' practice and enhancing their retention of learned knowledge (especially for the knowledge that may require repeated practice to remember) or as scaffolding pointers to guide students' learning.

Format or delivery platform

Because short lessons are like mini-lessons supplemental to the main course or curriculum, delivery can occur in the form of short videos, podcasts, or animation. On the other hand, JIT can be delivered in a wide variety of formats, such as videos, job-aids, or cheat sheets. The two latter formats can serve as extra "cheat sheets" for reference during the actual performance of the skills. Flash lessons, due to their fast-paced nature, utilize predominantly mobile devices to communicate between students and instructors. Therefore, short text messages or flash (e)cards, or any forms that convey necessary information in bite-sized bits, can be good candidates for conducting flash lessons.

Instructional strategies

The majority of the studies reviewed in this paper did not discuss the instructional design aspect of their projects. This finding is not surprising as one common purpose of these studies was to test the feasibility and effects of microlearning as an instructional mode, rather than its pedagogical soundness. As Hug (2021) asserted, "While pedagogy is a widely used concept in education policy, research, and practice, the terms 'sound pedagogy' and 'microlearning' appear rather rarely in these arenas." Nevertheless, based on the information shared in these studies as well as the researchers' knowledge in instructional design theories and experience training industry, we offer some suggestions for designing the three categories of microlearning instruction. For short lessons, though they look similar to regular courses in format and structure, they are intended to be short. Therefore, short readings are critical to keep the learners' attention. Use of multimedia is also important as this form of information presentation is in line with current information-consuming behavior patterns. Also, providing examples and non-examples for easy comprehension of the content information is one key to effective instruction, as demonstrated in Gross et al.'s (2019) study. JIT, on the other hand, serves better in procedural knowledge learning, clear demonstrations and explanations of steps, how to preform each step, as well as the order of the steps. Videos and audios should be clear, and animations should be easy to understand and follow. Another helpful approach would be to include an audio-only (specific) instruction component for the learners to follow without having to watch the demonstration while practicing the skills. Lastly, flash lessons should be released on a regular and consistent schedule so they can properly guide and regulate students' learning and pace. Because short text messages or images on mobile devices are used as the main communication platform, providing short, concise, and only essential information is a key principle of the effectiveness of flash lessons.

Implications for training industry

The shift in the corporate training industry to embrace microlearning instruction has been ongoing for several years. Industry conferences, articles, and blogs have focused on microlearning as a mainstream topic (such as how to create lessons, when to use them,

determining the optimal audience for this instructional strategy, and so on) (Andriotis, 2018a; Ghosh, 2016; Hogle, 2018; Torgerson & Iannone, 2019; Watmough, 2019). As a result, some organizations are already pushing for the development and implementation of microlearning. However, the principles and guidelines for designing and implementing microlearning lessons are still mainly anecdotical, rather than evidence-based. It is important for the instructional designers who are on the creating end of the industry to be aware of that evolution. More importantly, instructional designers must adopt research-based and evidence-based best practices for the use of microlearning to meet demands of learners and the everchanging challenges in the training industry and academic education.

Moreover, this scoping review showed that microlearning trainings seemed to be especially effective as supplemental support for larger-designed learning programs. This finding may help provide a better position for the use of microlearning. A further question should also be considered: what category of microlearning would better afford specific learning needs? More research in the affordance of short lessons, flash lessons, and JIT may equip instructional designers with a better understanding of these microlearning format options and help them use the formats effectively. All of these options create opportunities to design and implement many different venues of learning moments, outside of traditional methods. Creative thinking in how to use such flexibility will be an interesting challenge to put into practice.

Limitations

Limitations for this scoping study include the sample size of included studies. With the relative "newness" of microlearning, the use of database search filters, and the inclusion/exclusion criteria, the resulting total of 13 studies provides an intriguing look at the trends and effects of microlearning training for learners' performance. A larger sample size will undoubtedly verify some of the findings in this scoping study and reveal more nuances for further research.

Conclusions

The focus of this scoping study is to survey trends of employing microlearning for training purposes in education and the workplace as well as its effects on enhancing learner performance. The interest in how microlearning training impacts learner performance is based on the notion that the benefits of these shorter, concise, and single-topic e-learning trainings create a direct relevance to learners or trainees' specific needs. While this assumption appears to be accepted and discussed in professional studies fields and corporate training industry, empirical research on the effects of microlearning, as well as its design principles and implementation guidelines, are still scarce and mono-disciplinary (mainly in medical/healthcare fields), as this scoping review discovered. More empirical studies on the effects of microlearning on student learning outcomes and the learning process, as well as the best practices in different educational contexts (including professional studies disciplines, different educational levels, and academic or corporate training environments), will be needed to inform us of the best practices of utilizing this emerging pedagogical approach.

Declarations

Conflict of interest Authors declare that they have no conflict of interest to disclose.

Research involving human and animal participants N/A.

Informed consent N/A.

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