A STUDY OF LEARNER EXPERIENCE DESIGN AND LEARNING EFFICACY

OF MOBILE MICROLEARNING IN JOURNALISM EDUCATION

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A Dissertation

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by

YEN-MEI LEE

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The undersigned, appointed by the Dean of the Graduate School, have examined the

dissertation entitled

A STUDY OF LEARNER EXPERIENCE DESIGN AND LEARNING EFFICACY OF

MOBILE MICROLEARNING IN JOURNALISM EDUCATION

presented by Yen-Mei Lee,

a candidate for the degree of Doctor of Philosophy,

and hereby certify that, in their opinion, it is worthy of acceptance.

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TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

ABSTRACT

With the increasing number of mobile technologies, people rely on smartphones to connect with the world and obtain news and information. The emergent use of mobile technologies changes the way journalists produce and disseminate news. It is important for journalism educators to know how to support journalists' digital skills development, particularly digital skills of mobile technologies, and understand which new forms of learning are suitable and feasible for those learners in the journalism sector.

Previous research has shown that mobile microlearning (MML) can be a promising learning approach for specific learning needs. Mobile microlearning basically means learning no more than five minutes of lessons that are distributed on the smartphone. However, there is only a little evidence on the design and effects of MML in the context of journalism education research. Hence, this dissertation aims to examine whether MML can be a useful approach to facilitate mobile journalists' digital skills learning with smartphones.

Adapting a sociotechnical-pedagogical learner experience framework with a user-centered design process, a four-phase formative research cycle was conducted in this dissertation: Phase 1, a systematic literature review of mobile microlearning (Study 1), Phase 2, a needs assessment for an understanding of mobile journalists' learning needs and requirements (Study 2), Phase 3, an iterative design and development of a mobile microcourse and studying its usability and user experience (Study 3), and Phase 4, an examination of the learning efficacy (i.e., effectiveness, efficiency, and appeal) and learner experience of the developed mobile microcourse (Study 4). A mixed-method data collection and analysis approach was applied throughout this dissertation. The results in

this research provided evidence-based findings and indicated that MML is a feasible and effective approach to support mobile journalists' just-in-time learning when the MML designs follow four sequential design principles: (a) an aha moment to help with the learners connecting their previous experiences to the importance of current learning topics, (b) interactive content, (c) short exercises, and (d) instant automated feedback. Lastly, the dissertation discussed the results and addressed insights and implications of the MML design to improve learner experience and learning efficacy.

Keywords: Mobile microlearning, mobile journalism education, formative research, adult learning, meaningful learning, learner-centered design, sociotechnical pedagogical learner experience design, learning efficacy

Chapter 1: Introduction

People spend more time obtaining first-hand, real-time news content on their portable mobile devices especially smartphones than they do watching TV channels or reading newspapers (Umair, 2016; Wurmser, 2019). Thus, in journalism, news and media have moved from a 24-hour, ready-made package cycle to a minute-by-minute updated digital and mobile format (Costello & Oliver, 2018). This new practice is forcing journalists to report the news as soon as they gather it, digest it, and break it down into smaller pieces to become mobile-friendly content (Burum & Quinn, 2015; Wenger et al., 2014). As a result, a new type of journalist has been born: the **mobile journalist (MoJos)**. MoJos have become pioneers in this natural change of journalistic practice (Karhunen, 2017) and smartphones have become a comprehensive production resource in MoJos' daily work routines (Salzmann, Guribye, & Gynnild, 2020) as it allows MoJos to process information within minutes on the go and rapidly report it anywhere, at any time (Cervi, Pérez Tornero, & Tejedor, 2020; Kitsa, 2019; Salzmann et al., 2020; Westlund & Quinn, 2018).

A mobile journalist works with the feature of "all-in-one-device" (Karhunen, 2017, p. 31) on smartphones; which means that a MoJo directly uses his or her own smartphone independently gathering and processing the news on the go and then disseminating the news to the mobile news audiences–people using mobile applications such as Social Media (e.g., Facebook, Twitter) to read online news (Kolodzy, 2013; Umair, 2016). This description of MoJos seems to be similar to the characteristics of "citizen journalist" which is defined as people who have an opportunity to use the technologies to capture information, create photographs or videos and upload the content

to their blogs or social media when witnessing any surrounding events (Barnes, 2012).

But it exists a difference between professional journalists (MoJos) and citizen journalists

(Örnebring, 2013). Compared to citizen journalists without professional or formal

training in journalism (Barnes, 2012), MoJos have the knowledge and skills to filter

information, make an editorial judgement (i.e., select and grasp news values), *know how*

to transform events that match the news values into narratives accessible to newsreaders,

and have a trustworthy relationship with the audiences since they are trained to present

their professional code of ethics and societal duties in the work while reporting the news

to the public (Örnebring, 2013).

On the other hand, MoJos' working practices are different from traditional

journalists and online journalists. Traditional journalists are mainly trained in a way of

linear writing with narrative text in print newspapers or magazines; online journalists

mainly focus on the skills of web-based non-linear writing in a storytelling format and

with relevant graphics or hyperlinks using the Internet and computers; mobile journalists

are emphasizing the skills of spotlight writing to disseminate bursts breaking news on

social media platform (e.g. Twitter, Facekbook, LinkedIn) on the go using smartphones

or mobile devices (Al Jazeera Media Training & Development Center, 2017; Bui &

Moran, 2020; Hermida, 2010, Višňovský & Radošinská, 2017). In addition, compared to

traditional and online journalists, MoJos need to possess specific digital and mobile skills

for supporting their work such as writing concise headlines and bite-size stories for

mobile audiences, using smartphones to process audience analytic, applying

multiplatform skills (especially mobile apps) to direct traffic to the news outlet, and

shooting and editing videos and audios from the field on the go with mobile devices

(Wenger et al., 2014; Wenger et al, 2018). Figure 1 shows the characteristics of MoJos versus traditional journalists and online journalists.

Figure 1

Mobile Journalists' Digital Skills Versus Online Journalists and Traditional Journalists

Traditional Journalists	**Online** Journalists	**Mobile** Journalists
• Linear Writing/Narrative Texts • Ready-made package • One-way communication • Print Papers, Magazines	• Non-linear Writing • Storytelling • Hyperlinks, Multimedia • The Internet, Computers	• Spotlight Writing • Breaking News Bursts • Mobility, Multimedia • Smartphones, Mobile Devices
Basic Skills News gathering, writing, editing, interviewing, photo shooting ***Digital Skills*** Use computer software editing, processing, reporting news, use cameras	***Basic Skills*** News gathering, writing, editing, interviewing, photo shooting ***Digital Skills*** Use computer software, web browsers, search engines processing and editing news, filming audios & videos, use cameras	***Basic Skills*** News gathering, writing, editing, interviewing, photo shooting ***Digital Skills*** Use mobile devices, Webs and Apps recording, editing, and creating news, filming audios & videos, use smartphone cameras and recorders ***Mobile & Digital Skills*** All the work is completed on mobile devices and on the go

Note. Figure 1 Adopted from literature: Al Jazeera Media Training & Development Center (2017), Bui & Moran (2020), Deuze (1999), Hermida (2010), Višňovský & Radošinská (2017), Wenger et al. (2014).

When they are going about their tasks, MoJos may encounter problems that are related to digital and or digital-mobile skills that they have not learned in their education (Maniou et al., 2020). For example, they need specific techniques to record interviews with their smartphones from the field or they need immediate guides or examples to generate short news headlines on the go, and they have the demand to learn a solution "anytime, anywhere, anyhow" (Brandenburg & Ellinger, 2003, p.308) that can

immediately impact the work (Costello & Oliver, 2018; Knowles, 1980). These unique skills require additional learning, often on-demand is also understood as "just-in-time learning" which allows people to obtain "just-in-time job-related knowledge, onsite and at the point when needed" (Alade, Welch, Robinson, & Nichol, 2020, p. 198). Accordingly, there is a need to figure out new forms of effective learning to support MoJos' specific learning condition, the goal-oriented and self-directed learning process (Knowles, 1980; Maniou et al., 2020).

Mobile microlearning (MML) may be an engaging solution to meet MoJos' needs of just-in-time learning (Costello & Oliver, 2018). The key concept of MML is to customize bite-size learning materials into mobile applications with no more than five minutes per learning unit (Jahnke et al., 2020). In addition, the term "mobile" in MML also means that the learner is "mobile." Because of its learn-on-the-go principle that people are able to search and acquire knowledge or skills using smartphones or mobile devices anytime at their convenience (Dingler et al., 2017; Emerson & Berge, 2018), learners have the flexibility and mobility to situate their learning with smartphones by accessing the MML lessons anytime and anywhere, for example, five minutes in the bus, waiting in a line for a cup of coffee, or traveling from and to work, and pause the content at their own pace (Grant, 2019). An example of the designs for MML is shown in Figure 2, which shows only one single concept at once and provides short, simple, and bite-size sentences and images on a mobile screen (Jahnke et al., 2020).

Figure 2

An Example of Designs of Look & Feel for Mobile Microlearning on a Smartphone in

General
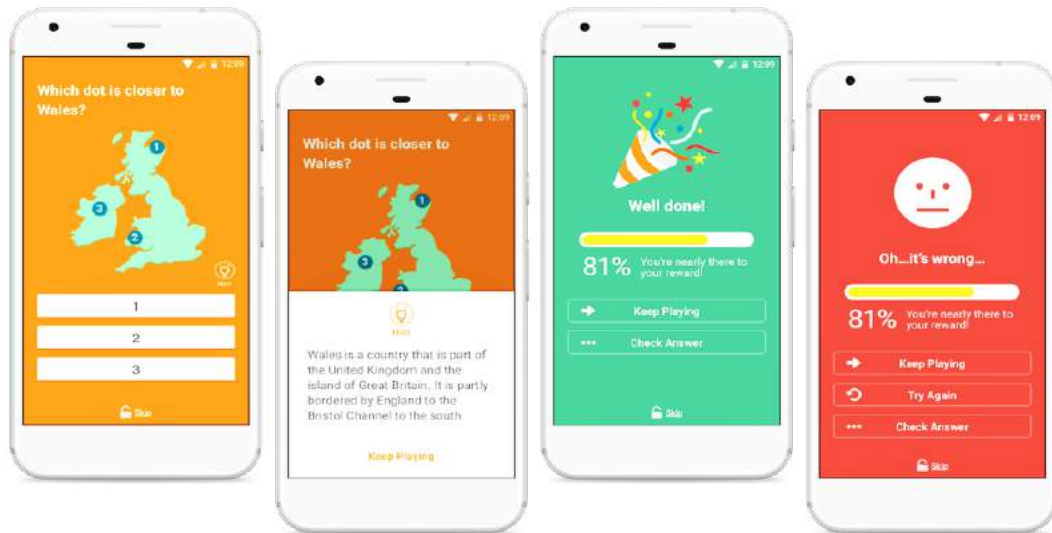
Note. The MML feature is retrieved from PAZZPUZZLE (Lo, 2020). The Source URL: http://www.rachaello.com/pazzpuzzle.

To support a comprehensive learner experience (LX), a complete learning design should include the pedagogical (e.g., learning goals, learning activities, and assessments), the technological dimensions (e.g., digital technologies, tools, platforms, devices), and the socio-cultural dimensions (e.g., collaborations, communication, and other social interactions and relationships) (Jahnke, Schmidt, Pham, & Singh, 2020). In the MML approach, the design concept emphasizes the presentation of self-paced, short, and pocket-size learning contents (pedagogical dimension) and the implementation of mobile platforms or applications with smartphones and mobile devices (technological dimension). It seems that MML focuses on the pedagogical and technological dimensions while it does not sufficiently address the social dimension. To understand whether MML

can support the whole LX and fulfill journalists' learning needs, a detailed literature review and investigations are needed to clarify what has been done in previous work and what is still absent in MML research and journalism education.

In summary of this introductory chapter, an overview of the mobile journalism practice and the assumption that MML can be a potential alternative learning approach to support MoJos' learning are addressed. In the next section, the problem statements of this research and their guiding research questions are addressed.

Problem Statement and Research Questions

In this section, the exploration gaps in the field of mobile journalism education and the approach of MML are pointed out, and further motivated by these exploration gaps, central research questions and the goal of this dissertation are addressed.

In journalism education, Wenger et al. (2014) and Wenger et al. (2018) investigated more than 18,000 job positions from the top 10 news companies in the United States and found that the essential criteria that a qualified candidate needs to have are digital skills on mobile devices. According to the synthesized review, Wenger et al. (2018) propose a set of *digital mobile skills* to guide mobile journalism education such as writing better headlines and stories for mobile audiences, shooting and editing videos and audios with mobile devices, and using social media skills for storytelling or personal branding. However, Wenger et al. (2018) also argue that the mobile technology area is rapidly changing and it is difficult for educators in journalism to clearly understand what specific digital skills that MoJos *perceive the need* for their readiness to work in the digital journalistic practice. Moreover, literature shows that research in the journalism education has mostly targeted journalism educators' professional perspectives on how

they develop an effective training model or a series of curriculum (Bui & Moran, 2020; Maniou, Stark, & Touwen, 2020) but has been seldom studied from the learners' perspective to understand the types of specific digital skills that journalists actually *expect*, *desire,* or *need* to learn in addition to the capacities they already have. From a learner-centered education standpoint, Norman and Spohrer (1996) emphasize that it is necessary to focus on "the needs, skills, and interests of the learner" (p.26) when constructing a learner-centered learning environment. With the explored concerns, the first research question of this dissertation is addressed:

> *RQ 1: What are the mobile journalists' learning needs of digital skills with smartphones that support their on-demand learning, and can MML be perceived as a useful approach?*

In terms of the approach of MML itself, in literature, a cohesive set of MML design principles relating to learning activity designs, the sequenced instructional flows, and pedagogical usability of microcontent interaction has been identified (Jahnke et al., 2020). In addition, MML has been applied in several types of academic contexts and real-world practices. For example, Nikou and Economides (2018) developed mobile-based micro exercises as homework to improve high-school students' science learning, and Pham and Chen (2019) applied image-based mobile flashcards to enhance second language capacities. As for the practical implementation of MML, many web and mobile applications have been developed as media to support online and distance learning such as *Grovo* which is to master employees' performance, *Lynda.com* which is to enhance software and business skills, and many other MML platforms such as *Skillshare*, *Udacity*, *Udemy*, etc.

7

MML is formed by two essential codependent factors, the design of digital technology and the instructional method (Lee, Jahnke, Austin, 2021). From a constructivist perspective, Dabbagh, Marra, and Howland (2018) state that meaningful learning focuses on learning *with* technology rather than *from* it. An effective design to promote learners' meaningful learning outcomes with technologies consists of three design components: instructional strategies, learning activities, and proven learning technologies (Dabbagh, Marra, & Howland, 2018). Keeping this meaningful learning framework in mind, MML in literature seems to be focused on the investigation of instructional strategies and learning activities (e.g., Nikou & Economides, 2018; Pham & Chen, 2019), however, the examination of proven learning technologies, i.e., the design of technology and its affordances such as user experience and usability evaluations, is relatively neglected (Chai-Arayalert & Puttinaovarat, 2020; Ohkawa et al., 2018; Rensing, 2016). Sauro and Lewis (2016) and Nokelainen (2006) address that usability testing, including both pedagogical and technical usability, plays an important role in the context of developing a learning technology because it can identify potential problems that users perceive difficulties when interacting with the learning technologies. However, in the MML literature, Chai-Arayalert and Puttinaovarat (2020) notice that there is a lack of empirical guidance to design meaningful learning contents into small screens as well as a lack of usability evaluation of MML to ensure the designs are easy to use and understandable by the learners. Given this problem statement, the second research question of the dissertation is addressed:

> *RQ 2: What are usability issues and challenges when developing a MML platform, and how should the user experience be improved?*

Two above proposed research questions take this dissertation to the third problem statement. When bringing the field of journalism education and MML approach together, there is a limited amount of education research addressed whether designs of MML can be an effective approach to positively affect MoJos' learning experiences and enhance their performance outcomes (Jahnke et al., 2020; Umair, 2016). A successful instruction can be evaluated based on the three learning outcome values–effectiveness, efficiency, and appeal (Reigeluth & Carr-Chellman, 2009). However, there is a lack of evidence in the literature on whether the design and application of MML is an effective format to enhance MoJos' learning of digital skills with smartphones. Given the identified gap, the third research question is proposed:

> *RQ 3: To what extent does a specific developed mobile microcourse facilitate learning efficacy (effectiveness, efficiency, and appeal) and the learner's experience (mobile journalists' learning experience), and does this MML design contribute to the desired learning outcomes?*

Shedding light on the problem statements relating to mobile journalism education and MML, **the major goal of this dissertation is** to contribute to the body of knowledge in the field of MML and mobile journalism education to provide insights into how the design of a mobile microcourse can fulfill MoJos' learning needs and foster their positive learner experience and learning process.

Summary of Research Questions

The three central research questions (RQs) are summarized as follows:

RQ 1: What are the mobile journalists' learning needs of digital skills with smartphones that support their on-demand learning, and can MML be perceived as a useful approach?

RQ 2: What are usability issues and challenges when developing a MML platform, and how should the user experience be improved?

RQ 3: To what extent does a specific developed mobile microcourse facilitate learning efficacy (effectiveness, efficiency, and appeal) and the learner's experience (mobile journalists' learning experience), and does this MML design contribute to the desired learning outcomes?

Organization of the Dissertation

This is a four-article dissertation. Aligned with the research goal and the three central research questions, four objectives are demonstrated in this section. Each objective consisted of one study and a total of four studies were conducted in the dissertation. Ultimately, the four studies aims to become publishable scholarly papers, and two of them have been published in peer-reviewed journals. The following four objectives with their developed studies are:

First, to get familiar with the context of MML in previous related work, the first study was developed using the method of Systematic Literature Review (SLR) aiming to understand the trend, impacts, challenges, and potential gaps of the MML approach. The literature review result is presented in Chapter 2 and developed as Study 1 (Appendix 1).

Second, to answer the first research question, the second study was conducted using a semi-structured survey method aiming to investigate MoJos' learning needs of digital skills with smartphones and examine whether MML is perceived as a useful

approach to facilitate their learning needs. This study is introduced in Chapter 3 and developed as Study 2 (Appendix 2).

Third, to answer the second research question, the third study was conducted using a formative usability research approach aiming to reveal potential user experience and usability issues and identify improvement recommendations for a MML course that was designed and developed for MoJos' digital skills development. The content materials and instructional design sequence of this developed MML course were informed by the results of Study 1 and Study 2. This usability study is introduced in Chapter 3 and developed as Study 3 (Appendix 3).

Fourth, to answer the third research question, the fourth study was conducted using a formative research approach with a mixed data collection and analysis method aiming to assess the design and effects of the MML course in relation to MoJos' learning efficacy (effectiveness, efficiency, and appeal) and their learner experiences. This final study is introduced in Chapter 3 and developed as Study 4 (Appendix 4).

An overview of the organization of the dissertation is shown below (Figure 3).

Figure 3

Organization of the Dissertation

	Phase 1	**Phase 2**	**Phase 3**	**Phase 4**
Objective	To get familiar with the context of use in the MML approach	To specify MoJos' needs & investigate whether MML is a potential approach to support MoJos' learning	To develop a MML course based on study results informed by Phase 1 and Phase 2 and test its usability	To implement the MML course in mobile journalism and assess MoJos' learning efficacy and learner experience
Data	A systematic literature review of MML studies between 2015 and 2020	A semi-structured survey method of the target learners (MoJos)	A MML course design & development using a set of MML design principles; a usability study with expert review & usability test	A mixed-method empirical intervention to examine MoJos' learning efficiency, effectiveness, and appeal
Developed Study	*Study 1* *A systematic Literature Review of MML (Paper 1 manuscript in Appendix 1)*	*Study 2 (RQ1)* *Needs Assessment of MoJos' Learning Needs and Learner Experiences (Paper 2 manuscript in Appendix 2)*	*Study 3 (RQ2)* *An Iterative Usability Testing of the developed MML course (Paper 3 manuscript in Appendix 3)*	*Study 4 (RQ3)* *A Study of MoJos' Learning Efficacy and Learner Experience with the MML course (Paper 4 manuscript in Appendix 4)*

Chapter 2: Theoretical Framework and Literature Review

This chapter consists of three sections. The first section introduces the theoretical framework of the sociotechnical-pedagogical learning experience to shape the central philosophy of MML research in this dissertation. The second section addresses three key concepts of the MML approach retrieved from a systematic literature review results to support the main purpose of this dissertation. The third section demonstrates the research framework of this dissertation and shows how the sociotechnical-pedagogical learning experience framework is connected to a user-centered design process to tight up the entire research.

Theoretical Framework–Socio-Technical-Pedagogical Learner Experience

User or learner experience design and research is based on human-computer interaction (HCI) that is an interdisciplinary research field including, such as, engineering, cognitive psychology, and social science, and offers a way to comprehend how users interact with digital technologies, systems, or services (Good & Omisade, 2019; Gray, 2020; Kim, 2015). The goal of HCI is to design ease of use interfaces, develop efficient interactions between the users and the systems, and ultimately optimize the *user experience* and *usability* (Kim, 2015). In this dissertation, usability is understood and used as the extent to which the system can be used by specified users to achieve certain goals with effectiveness, efficiency, and satisfaction during a specified context of use (Sauro & Lewis, 2016). User experience (UX) describes a broader context of technology usage that refers to users' perceptions, responses, and subjective feelings (e.g., pleasing or frustrated) of interacting with the system over time (Schmidt et al., 2020).

The main design principle of HCI is to "know thy user" originated by Hansen (1972); it means the interaction and interface should be centered to the needs of the target users when designing a specific system (Kim, 2015). From a historical perspective, this concept later extends to "user-centered design" (UCD) coined by Donald Norman's research team in the 1980s (Norman & Draper, 1986). The philosophy of UCD also puts the defining tenet on placing the target population at the center of design decisions to understand users' expectations, desires, and needs throughout all phases of design (Schmidt et al., 2020).

User-centered approaches to design have been accepted as especially useful in supporting a positive user experience (Schmidt et al., 2020). However, user experience studies focus on the user's interaction with the digital technology but do not address learning efficacy or learning effectiveness. Therefore, I add to the UX framework the perspective of the learner experience (LX) design and research framework (Jahnke et al., 2020). This rather new LX framework leads to question how the methods and processes of the user-centered UX and usability research correspond to how we design and develop *learning*. Jahnke et al. (2020) argue that developing a positive LX with learning technologies is more than just evaluating the UX or usability; it also is concerned with the learner's interaction with pedagogical elements and with the social contexts such as the whole community of learners and teachers.

Integrating UX and LX research can be fruitful as it sheds light on both the usability and the efficiency, effectiveness, and appeal of learning (Honebein & Honebein, 2015). Literature shows higher technological usability promotes better LX than those with lower technological usability (Althobaiti & Mayhew, 2016; Jahnke et al., 2020).

However, positive UX outcomes alone can only improve the system but not be specifically helpful to predict positive LX (Schmidt et al., 2020). It means LX is not just a brief use of information with short-term memory to interact with or perform something and then forget it, but it is a continuous and iterative process to experience the differences and transformations before and after engaging in a specific learning intervention (Bowen, Forssell, & Rosier, 2020; Ormrod, 2011).

LX has a broader interconnected relationship between learner's interaction with the designed learning technologies, the pedagogical elements, and the socio-cultural context (Jahnke, 2015; Schmidt et al., 2020). Jahnke et al. (2021) write,

A learner's experience encompasses all aspects of a learner's interaction with: (a) the digital technology, service, or space; (b) the pedagogical components, such as course type, learning goals, learning activities, process-based assessment, and learner control; and (c) the social dimension, such as quality of communication forms, collaboration, sociality, social presence, and social interactivity (p. 19).

Jahnke et al. (2021) explain that LX encompasses three study dimensions: the technological, the pedagogical, and the social dimension, and name it in short the sociotechnical-pedagogical learner experience.

Technological dimension is defined as usability related to technological issues; *pedagogical dimension* includes the learning and instructional strategies, concrete teaching or learning goals, instructions, clear scaffolding and supports, and meaningful learning activities, and assessments; and *social dimension* indicates human and human interaction by means of technological tools, social presence, and social roles or

relationships (Jahnke et al., 2020). The three dimensions are indispensable components shaping the whole LX. The holistic view of the LX framework is illustrated in Figure 4.

Figure 4

A Framework of Sociotechnical-Pedagogical Learner Experience. Inspired by Jahnke et al. (2020, Discussion Section, para. 1)
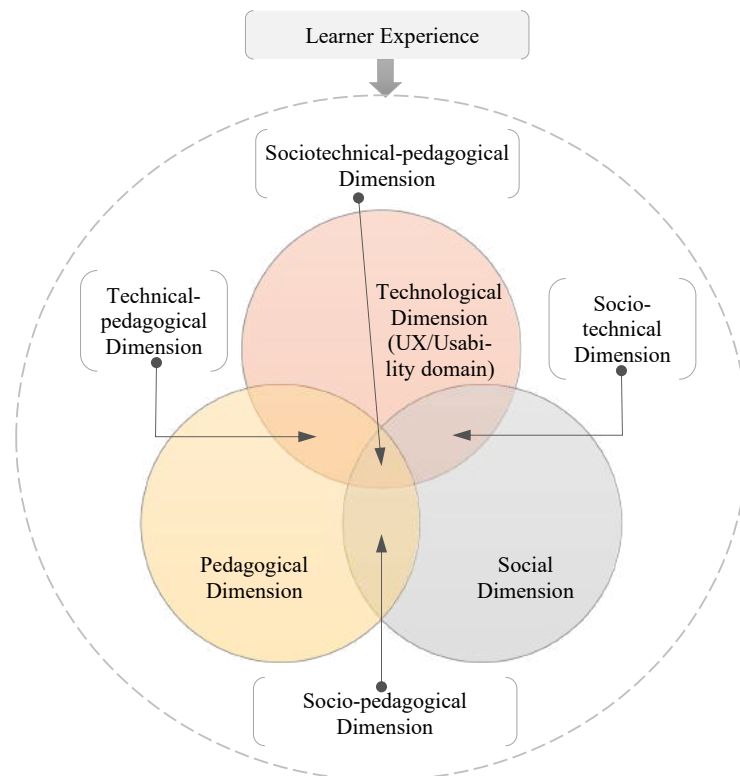
Figure 4 shows the intersections of the three dimensions include the socio-technical dimension, the socio-pedagogical dimension, and the technical-pedagogical dimension. Each intersection consists of its unique meaning:

- *Socio-technical dimension* emphasizes that user-friendliness of online social presence plays a critical role in developing a learning community, facilitating active learning, and engaging learners in the learning context with

technologies.

- *Socio-pedagogical dimension* addresses that a responsive or supportive community of learners in online or hybrid learning is necessary to promote a positive LX while a pedagogical dimension with meaningful learning elements is necessary for an active learner-centered learning approach.

- *Technical-pedagogical dimension* indicates that technological usability is an essential part of the whole LX design to identify learners' perceptions of ease of use with the learning technologies and the pedagogical dimension can support the learning/instructional designer's perspective on how to demonstrate and deliver teaching goals, learning objectives, learner activities, and assignment methods for each learning design.

In summary, this dissertation indented to integrate the sociotechnical-pedagogical LX framework to investigate the learners' experiences and interactions with the digital environment (UX, usability part) but also to include the pedagogical and social dimension (LX parts). Before applying the LX framework to guide the development, analysis, and refinement (Bowen, Forssell, & Rosier, 2020) of the MML design in this dissertation, an overview of MML research in terms of how MML was applied to improve LX and learning process in previous literature was conducted by a systematic literature review and the review results are presented in the following section (Literature Review of MML Research).

Literature Review of Mobile Microlearning Research

Mobile microlearning (MML) bridges the two concepts of microlearning and mobile learning (Huo & Shen, 2015; Peng, 2017), and is defined as a series of

short-period of learning units ranging from 30 seconds to five minutes on average

per lesson and created purposely on mobile applications to support individualized

learning at anytime, anywhere, with smartphones (Jahnke et al., 2020).

In order to better design, develop, and evaluate the MML design in the

context of mobile journalism, a systematic literature review of MML was initially

conducted to have an overview of its characteristics, trends, impacts, and

challenges (see Figure 3 in Chapter 1: Phase 1 of the Dissertation Organization).

The entire literature review study is listed in Appendix 1 (Study 1). According to

the review result, three key concepts of MML research are addressed, including the

informal and just-in-time learning in adults' professional training, the learner needs

and learning experience as impact factors of MML outcomes, and the application of

learning efficacy in MML. Descriptions of each concept are addressed as follows.

Informal and Just-in-time Learning of MML in Adults' Professional Training

Literature reviewed shows 46.15% of MML studies published between 2015 to

2020 applied informal setting to support learners' mobile-based microlearning and

26.92% of the MML studies focused on professional knowledge and skills development

in the workplace (see results in Study 1 in Appendix 1). The informal setting is defined as

learning that can go beyond classroom-based school systems and occur anytime,

anywhere in a critical moment of needs in our daily lives when we have demands,

desires, or interests to learn something new (Bano et al., 2018; Manuti et al., 2015);

relative concepts are formal setting and non-formal setting, the former means the context

of traditional classroom-based environments which is followed structured school

timeframes and planned curriculum and the later means any systematic learning activities

for a specific population such as seminars, workshops, and conferences (Nelson, Cushion, & Potrac, 2006).

In an informal MML approach, a variety of learning designs have been addressed in previous literature such as the design of a mobile flash-card for second language building (e.g., English and Mandarin) (Pham & Chen, 2019), the design of virtual and interactive location-based GPS exercise for liberal art and ecology education (e.g., Chai-Arayalert & Puttinaovarat, 2020; De Troyer et al., 2020), and the design of quiz-based activities for healthcare knowledge building (e.g., Simons et al., 2015). But the most focused domain in the context of informal MML is for employees' workplace training such as the application of a series of game-based micro activities for professional skills development on the topic of nursing education (ONeill et al., 2018), civil service management (Norsanto & Rosmansyah, 2018), and baking (Göschlberger & Bruck, 2017).

Looking in-depth into the context of informal MML for workplace trainings, the just-in-time learning approach–with where the essential learning contents and exercises are readily accessible, absorbable, and actionable when learners need them–is an advantage (Hudson et al., 2020; Hanshaw & Hanson, 2018; ONeill et al., 2018; Rensing, 2016). For instance, ONeill et al. (2018) embedded a gamified mobile microlearning application into nursing education aiming to increase nurses' professional knowledge and frontline staff' professional performances. They found that this just-in-time MML approach could successfully deploy action-oriented learning that allowed nurses and frontline staff to acquire and use the learned skills immediately in their daily workflows. Accordingly, it seems that the informal just-in-time learning approach of MML can

benefit people who work outside of the office or in a specific condition and have no time to participate in a long series of training sessions, for example, mobile journalists, who need to process breaking news from the field on the go.

However, the field of journalism is absent in MML research. The synthesized results of the MML literature review show that the outlet of learning topics in MML research is medical science, human-computer interaction (HCI), information, communication, and technologies (ICT), engineering, and business (see Appendix 1, the result is shown in Appendix 2 of Study 1). It is difficult to directly infer that MML is a promising solution to support journalism education, to be more specific, the population of MoJos. Thus, the dissertation aimed to fill this gap and provided an evidence-based examination on the designs and effects of MML to understand whether MML is a promising solution to support MoJos' learning process.

Learner Needs and Learning Experience–Impact Factors of MML Outcomes

Though 76.92% of the reviewed studies report that MML contributed to the increased success impacts on learning effectiveness (e.g., Hautasaari et al., 2019; Kadhem, 2017), engagement (e.g., Hanshaw & Hanson, 2018; Norsanto & Rosmansyah, 2018), learners' motivation (e.g., De Troyer et al., 2020), interests (e.g., Chai-Arayalert & Puttinaovarat, 2020), and fulfilling learner needs (e.g., Hudson et al., 2020; Wang et al., 2017), 11.54% of the reviewed studies do not have the same positive perspectives and state that the impacts of MML outcomes could be varied according to different situations and factors such as learners' experiences, knowledge structure, learning needs, and interface designs and developments of the MML platforms (Epp & Phirangee,2019; Göschlberger & Bruck, 2017; Sun et al., 2018). For example, Epp and Phirangee (2019)

conducted a repeated measures case study in a 12-week language learning intervention and found that not all types of learners had effective learning experiences in the MML approach. They clustered the participants into four types of learner, including the type of excited learners who started the learning session with high usage levels on the assigned MML platform but their usage dropped substantially over time, the type of responsive learners who continued their lower learning patterns with the MML platform during the entire learning intervention, the type of just-in-time learners who tended to learn on-demand knowledge and skills they were required to carry out, and the type of frequent learners who tended to maintain moderately high levels of usage and learning with the MML platform. Their results indicated that only the types of just-in-time and frequent learners had positive effects on their learning performances while the type of excited and responsive learners tended to focus only on the learning task they needed to complete but no further in-depth knowledge acquisition.

On the other hand, it is notable that 69.32% of the selected studies in this MML review utilized self-developed mobile apps as learning platforms to investigate learners' learning effectiveness, while the most issue (19.50%) identified by the review results was a lack of UX and usability test for the MML platforms. When looking back to the field of mobile journalism education, there is no further research indicating the characteristics and types of MoJos about their needs, experiences, and learning outcomes when learning in the context of MML as well as a clear guidance or reports regarding the UX and usability testing on these MML platforms. To carry out the gap, the dissertation aimed to investigate different types of MoJos in terms of their learning needs of the digital skills

development and examine UX and usability of MML platforms, and so the first and the second research questions (RQ1, RQ2) was addressed.

Learning Efficacy in MML–Effectiveness, Efficiency, Appeal

More than 80.76% of the reviewed studies address that MML research focused on improving professional skills and practical performances as well as concerned about the learning engagement, learners' motivations, perceptions, and enjoyment to learn in the MML approach (see Table 7 in Study 1 in Appendix 1). For example, De Troyer et al. (2020) applied a location-based mobile app with several kinds of mini-card information (e.g., a graphic with short annotations), instant feedback and bell notifications, and game-based interactive activities to catch learners' attention, and results indicated that this type of playful learning increased learners' intrinsic motivations and intentions to learn with the MML platform. Literature shows that from a learning efficacy perspective, the design of meaningful learning should take three outcome values into consideration, including learning effectiveness (i.e., learning achievement and performance), learning efficiency (i.e., the time spent on learning), and appeal of the learning content (i.e., learners' perceptions, attitudes, motivations, interests, and feelings of the learning content) (Honebein & Honebein, 2015; Reigeluth & Carr-Chellman, 2009). Taking into account the learning efficacy theory, the research for learning efficiency is relatively missing in the trend of MML literature compared to the other two components, effectiveness and appeal. Aligned with this observation, the dissertation aimed to equally include the three elements of learning efficacy into the research, and then the third research question (RQ 3) was addressed.

Informed by the results of the MML review addressed above, it is understood that MML literature mainly targets some but not all LX dimensions, particularly the pedagogical and technological dimensions. In the pedagogical dimension the literature focuses on learning outcomes, instructional methods and gamified learning activities and assessments (e.g., De Troyer et al., 2020; ONeill et al., 2018). From the technological dimension, the literature addresses a lack of user experience and usability testing on the developed MML platforms in MML literature. However, the literature review also shows that MML could not sufficiently convey the design concept from the social dimension; it means that the design for collaborative learning and the technology-mediated human-human interaction or communication in mobile microlearning is lacking. Because of the design nature of MML–as it is often self-paced and follows a short burst learning format– the design for the social aspect was relatively weak. Given this explored phenomenon, this dissertation intended to apply the sociotechnical-pedagogical LX framework to examine how the design of MML can support the whole LX framework–the social, technological, and pedagogical dimensions.

Research Structure of the Dissertation

In this section, a user-centered design process (ISO, 2010) was adopted as a foundation to guide the entire research structure of the MML dissertation and integrated with the three dimensions of the sociotechnical-pedagogical learner experience (LX) framework (Jahnke et al., 2020) to support the examination of MML experiences.

Adopting a User-Centered Design Process to Develop a Mobile Microlearning Experience

To ensure the design and development of the MML platform is centered on the needs of the learners (e.g., mobile journalists in this research), the framework of user-/human-centered design (UCD) for interactive systems (ISO, 2010) was adopted as a foundation to guide the entire research procedure. The following shows how the four action phases of UCD was applied in this MML dissertation (Harte et al., 2017):

Phase 1 is to identify the context of use of MML (Study 1);

Phase 2 is to specify the learner needs and experiences of MML in the context of journalism (Study 2);

Phase 3 is to develop and improve design solutions for MML (Study 3); and

Phase 4 is to study and improve the MML design against its learning goals and learner needs in the context of journalism education (Study 4).

UCD also highlights requirements that the design process should meet if the system development is to be considered a UCD methodology (Harte et al., 2017; ISO, 2010). These requirements are also adopted and applied for this MML research including:

Requirement 1, the design is based upon an explicit understanding of learners, learning tasks, and environments in the context of MML for journalism education; requirement 2, learners are involved throughout the MML design and development; requirement 3, MML design is driven and refined by learner-centered results of the research; requirement 4, the research process is formative; and requirement 5, the MML design addresses the whole learner experiences.

Figure 5 illustrates the research structure of the dissertation with a four-phase study process and it is also laid out in the Introduction section in Chapter 1 (see Figure 3).

Figure 5

Dissertation Research Structure–A Four-Phase Leaner Experience Design Framework
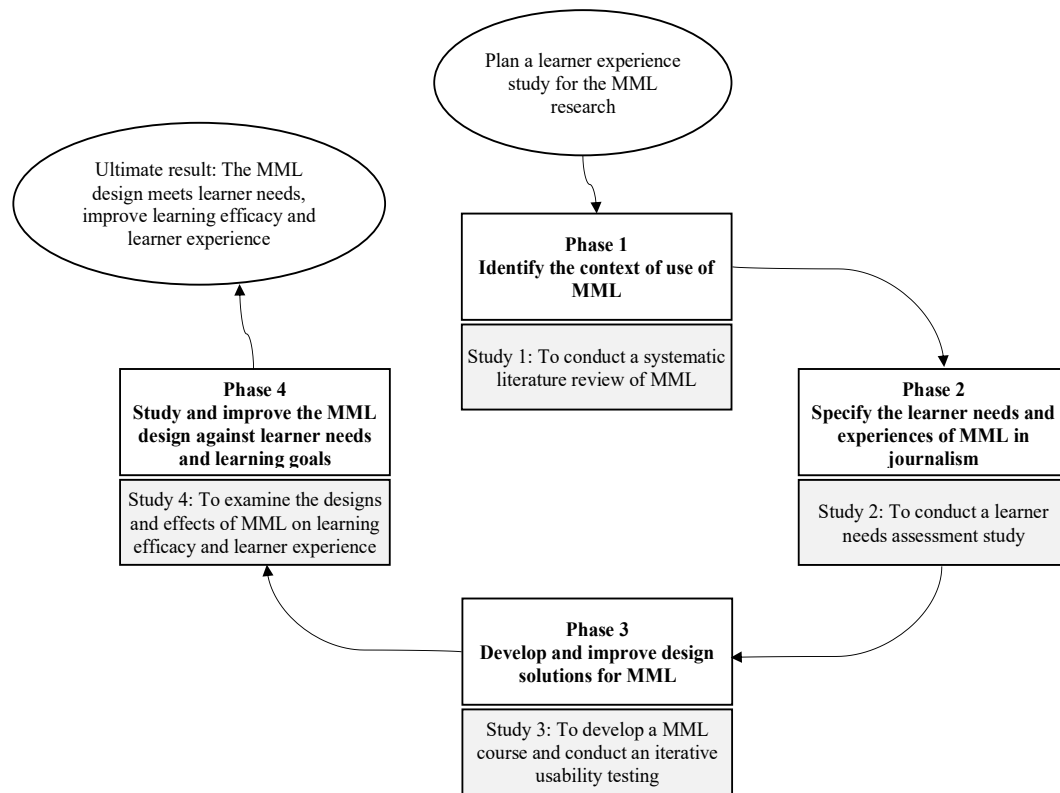
Four-Phase Research Structure of Learner Experience Design for this Dissertation

The following describes further details about how each study phase of the dissertation shown in Figure 5 is tailored to the three dimensions of the social, technological, and pedagogical dimensions of the LX research framework.

Phase 1: Identify the Context of Use of MML. This phase emphasizes the acquisition of an explicit understanding of the entire contexts, including types of learners, tasks, and environments (Good & Omisade, 2019). The outcome provides this dissertation with comprehensive background information that can contribute to the following design and evaluation stages of the developed learning platform (Love, 2005).

Accordingly, Study 1 of the dissertation aimed to understand the context use of the MML approach (social dimension), the type of instructional topics, learning outcomes, impacts of learners, and advantages and challenges of MML (pedagogical dimension) by conducting a systematic literature review (SLR) (Xiao & Watson, 2019).

Phase 2: Specify the Learner Needs and Experiences. This phase emphasizes the acquisition of learners' requirements and needs regarding the learning platform being developed (Love, 2005; Schmidt et al., 2020). The outcome of Phase 2 can provide a description of the types of learner needs, capabilities (physical and mental), skill levels, and previous learning experiences. The outcome also describes the kinds of expected functionality of the learning platform to support the learning process and provides the potential scenarios where the application can be designed into the learning platform (Kim, 2015; Love, 2005). Study 2 of the dissertation aimed to investigate the whole LX by conducting a survey-based needs assessment for understanding the different type of MoJos' characteristics (social dimension), the type of digital skills that MoJos perceive learn on demands (pedagogical dimension), and the experiences and perceptions of interacting with mobile technologies (technological dimension).

Phase 3: Develop and Improve Design Solutions for MML. This phase intents to develop a specific prototype of the intended MML platform and get feedback from the learners (end users) by conducting a formative usability testing (Harte et al., 2017; Love, 2005). Study 3 of the dissertation, therefore, focused on the design of an MML course for MoJos. It was an iterative user experience and usability study aiming to identify technical and pedagogical usability issues and understand users'/learners' perceptions after

26

interacting with the developed MML platform (technological-pedagogical dimension) (Hollingsed & Novick, 2007; Nielsen, 1993; Sauro & Lewis, 2016).

Phase 4: Study the MML Design Against Learner Needs and Learning Goals–Considering Learner's Experience and Learning Efficacy. This phase aims at studying the MML design and whether the design holds its promise, i.e., whether learners really learn what has been promised (Good & Omisade, 2019). Study 4 of the dissertation aspired to examine the *system design* from a UX perspective (technological dimension) and analyzed the *learning design* from a LX perspective (pedagogical dimension) to investigate the effects of the MML design on MoJos' learning efficacy (i.e., effectiveness, efficiency, and appeal) and LX.

A detailed description of the four studies of this dissertation are demonstrated in the next section, Chapter 3.

Chapter 3: Overview of the Four Studies (and Papers)

In this chapter, the four studies are introduced with the study goal, the theoretical background, methods, main results, and the implication and conclusion. Each study was developed to become a paper and was submitted to a journal. In three of the papers, I am the sole author, and in the fourth paper, I am the first author. As of today, two papers are accepted for publication. The current status of the four papers is as follows:

Study 1: submitted to the *Journal of Interactive Learning Environment (ILE)* (paper #1 in Appendix 1). Citation: Lee, Y. M. (under review, 2021). Mobile Microlearning: A Systematic Literature Review and Its Implications. *Journal of Interactive Learning Environment, x*(x), xx-xx.

Study 2: accepted in the *Journal of Journalism & Mass Communication Educator (JMCE*) (article #2 in Appendix 2). Citation: Lee, Y. M. (2021). Digital Skills of Mobile Journalists: Exploring Learning Needs and Learner Experiences of Just-in-Time Learning With Smartphones. *Journalism & Mass Communication Educator*, 10776958211001692.

Study 3: submitted to the *Journal of Usability Study (JUS)* (paper #3 in Appendix 3). Citation: Lee, Y. M. (under review, 2021). Iterative Usability Testing: Formative Evaluation of a Mobile Microlearning Course. *Journal of Usability Study, x*(x), xx-xx.

Study 4: accepted in the *Journal of Educational Technology Research and Development (ETR&D)* (article #4 in Appendix 4). Citation: Lee, Y. M., Jahnke, I., & Austin, L. (2021). Mobile microlearning design and effects on learning efficacy and learner experience. *Educational Technology Research and Development*, 1-31.

Study 1: Mobile Microlearning: A Systematic Literature Review and Its

Implications

Study Goal (Problem Statement)

A cohesive set of 15 MML design principles on the design of course structure, instructional flow, and usability issues was identified in earlier work (Jahnke et al., 2020). It is acknowledged that these synthesized design principles provide a set of guidelines that is helpful for developing a systematic mobile microlearning platform. However, having these design principles may not be sufficient to guide a comprehensive understanding of the trends and issues of MML research in the context of journalism education. Therefore, to fill the gap, this study aimed to map the trends and impacts of MML research and practices through a Systematic Literature Review (SLR). The submitted paper of Study 1 is listed in Appendix 1.

Theoretical Background

Systematic Literature Review (SLR) is a transparent and rigorous approach to systematically search, identify, select, extract, and analyze existing studies, and synthesize the results in sufficient detail (Xiao & Watson, 2019). Results of SLR can provide a comprehensive understanding of the trend and issues of domain-specific knowledge (Xiao & Watson, 2019). Thus, the dissertation followed the philosophy and principle of SLR to conduct this study.

Methods

The main purpose of this literature review was to identify the conceptual boundaries of the MML field and to receive an overview of what has been done in previous MML literature. Thus, this study did not conduct a *testing review* using

29

traditional meta-analysis (Glass, 1976) to statistically calculate the effect size

distributions of the selected articles (i.e., the weighted average of the intervention effects

of selected articles reflecting the amount of information that each article contains) but

apply a *descriptive review* using a scoping review approach (Arksey& O'Malley, 2005)

to provide a snapshot of the MML research such as the size of the pool of research, the

types of research settings, research outcomes, and any research gaps (Xiao & Watson,

2019).

In addition, to ensure the literature review answered the research questions of

Study 1 (*What are the general characteristics, including research purposes and the

source and year of publications, reported in MML studies? What are the research

settings, including learning domains, learning platforms, and supported learning

technologies, applied in MML studies? What are the research outcomes of learner

experiences, advantages, and challenges of MML as identified in MML studies?*), peer-

reviewed published articles were primary selected. Grey literature i.e., materials that were

unpublished, had limited distribution, and/or were not included in bibliographical

retrieval system (McAuley, Tugwell, & Moher, 2000) such as book chapters, reports,

proposals, and discussion forums that did not provide sufficient information to answer the

research questions were not included in this study.

Guided by Xiao and Watson's (2019) systematic literature review framework,

the study followed the sequenced structure of a five-step article selection process,

including initial article search and identification, screening, eligibility, quality

assessment, and the final selection of qualified articles. Five scholarly databases in the

fields of social science, medical science, and engineering were used to search the initial

relevant articles, including Google Scholar, ERIC, PubMed, ProQuest, and IEEE Xplore. Inclusion and exclusion criteria were identified and applied in the article screening and eligibility process. A quantitative content analysis method with a mixed approach of the deductive and inductive strategy was applied for data extraction, synthesis, and analysis (Graneheim, Lindgren, & Lundman, 2017; Riffe, Lacy, Fico, & Watson, 2019). The detailed methodology is presented in paper #1 listed in Appendix 1.

Main Results

The results found that MML has been widely applied in an informal education setting (46.15%), especially supporting the informal workplace training, compared to formal (30.77%), nonformal (15.38%), and blended learning environment (7.69%) (see Table 5 of paper #1 in Appendix 1). The majority of learning subjects examined in MML research included language learning (39.77%), workplace training (19.23%), engineering education (11.54%), science education (7.69%), lifelong liberal art education (7.69%), and nursing education (3.85%). Results also indicated that a mixed-method approach blended with a survey method, pre-and post-tests, and interviews have become a trend in MML studies in recent years (see Table 6 of paper #1). In terms of the impacts of MML, 76.92% of studies indicated that mobile-based microcontent with multiformat learning materials could enhance learners' achievement, learning engagement, learners' motivation and enjoyment, improved learners' knowledge and skills retention, supported learners the opportunity to learn at their own pace, and facilitated their information processing and reduced cognitive load (see Table 7 of paper #1). But results also found that 15.38% of the studies reported that not all the impacts of MML were positive which could depend on several factors such as learners' knowledge structure, experience, needs,

and the designs and organizations of learning materials on the mobile screens. Challenges of MML were also identified; the concerns appearing the most in literature were a lack of user experience and usability tests for the developed MML platforms (see Table 8 of paper #1).

Implication

Given the trends, impacts, and challenges of MML identified in the systematic literature review, four reflections and takeaway points were identified. First, it was noteworthy to know that the topic of journalism education seemed to be absent in the learning subjects identified from the MML literature. Second, learning outcomes and learner performances in the MML approach could be affected by learners' characteristics, learning needs, and their knowledge structure. These important factors were suggested to be taken into consideration when designing MML. Third, although MML platforms had been widely developed and applied, usability testing of these platforms was lacking. Because mobile microlearning is a combination of instructional and technological designs, it is necessary for future research to identify potential user experience and usability issues before delivering the developed MML platform. Lastly, the main outcome values identified in the MML literature review were focused on learning performance, achievement, engagement, and motivations, but how efficient the learners interacted with the MML platforms (i.e., the time or cost spent on learning) was unclear. Future MML design research is suggested to take the outcome value of learning efficiency into consideration.

Conclusion

This study (Study 1) contributed to the body of MML research identifying the trends, gaps, and challenges of MML. Aligned with the results and implications of the systematic literature review, this dissertation aimed to target the population of mobile journalists to investigate their learning needs and intended to develop a mobile microcourse to examine whether the designs of MML could be an effective, efficient, and appeal approach to support mobile journalism education. Therefore, the results of this study led to the next study: investigating MoJos' learning needs and the learner experience of digital skills learning with smartphones and understanding whether MML can be a potential approach to foster MoJos' learning process.

Study 2: Digital Skills of Mobile Journalists: Exploring Learning Needs and Learner Experiences of Just-in-Time Learning With Smartphones

Study Goal (Problem Statement)

According to Knowles's adult learning theory (1980), designing a high-quality curriculum for specific learners must first listen to what learners need and want to learn. But it seems that there is a lack of evidence-based investigation on what MoJos themselves want and expected to learn on digital skills with smartphones and how they experience learning. Furthermore, in real practices, MoJos may encounter problems that they have not learned in their professional training or schools before (Maniou et al., 2020) but from the field, they may have the need to acquire immediate solutions or suggestions which are useful to deal with the current problems or impact their work (Costello & Oliver, 2018; Knowles, 1980). Literature shows that smartphones can be used to deliver lessons for MoJos to solve problems (Costello & Oliver, 2018) and MML may be a potential solution to support MoJos learn just in time because it is able to

deliver small-size learning unit on mobile apps, which can be quickly grabbed and

absorbed by journalists (Costello & Oliver, 2018). However, evidence-based perceptions

of MoJos about the usefulness of the MML approach are lacking. Hence, this study

(Study 2) aimed to investigate learner needs and learning experiences in journalism

education. The article is listed in Appendix 2.

Theoretical Background

The adult learning theory (Knowles, 1980) was applied as a foundation to

support this study. The main concept of adult learning theory is that adults tend to learn

in a form of competency-development approach, goal-oriented and self-directed learning,

and they are likely to learn new things which are able to support them in problem-solving

and highly related to their life experiences and work practices (Knowles, 1980). That is,

adult learners desire "to apply whatever knowledge and skills they gain today to living

more effectively tomorrow" (Knowles, 1980, p. 44). Aligned with this theory, the study

demonstrated the discrepancy of MoJos' learner needs by adopting a learner needs

framework proposed by Knowles (1980) (see Figure 1 in paper #2 in Appendix 2), and it

indicated that MoJos' learning needs were presented in the discrepancy between their

current level of digital skills and the level of digital skills they expected to have.

Methods

A semi-structured survey method was applied with 835 potential participants of

the target population including journalism students, educators, professionals, and mass

communication and media (MCM) workers whose work was related to journalism. A

five-point Likert scale was used to investigate the learning needs of digital skills for

newsgathering using smartphones. Closed questionnaire responses were analyzed by

quantitative statistic methods (i.e., the one-way ANOVA, Pearson correlation coefficient, and the multiple regression analysis) (Benesty et al., 2009; Park, 2009) and open-ended responses were analyzed by content analysis with the frequency of counts on the identified attributes (Mayring, 2004).

Main Results (answer to RQ1)

Of 433 complete responses (62.75% response rate), results show that not only journalism students but also educators, professionals, and MCM workers have needs for developing their digital and mobile skills with smartphones. The high-demand skills they want to enhance included writing better headlines for mobile audiences, using social media skills such as Facebook Live stream and Snapchat function for storytelling, and creating simple graphics such as maps and charts on smartphones. Participants also propose certain advanced skills such as shooting and editing 360° videos, creating VR and AR videos, and basic programming and coding skills (e.g., HTML, CSS, and JavaScript).

Results from the multiple regression analysis found that different groups of MoJos had different demands on their digital skills development with smartphones depending on how they perceived the importance of skills for their journalism job requirements. In the analysis, the *independent variables (Xs)* are the skills that participants perceived important to have the skills that are required for the profession journalism job. The ten independent variables applied in this research were retrieved from Wenger et al. (2014) and Wenger et al.'s (2018) synthesized skills of job requirements from top 10 news companies, including *Using social media for reporting (X1), Using social media for personal branding (X2), Using Facebook Live stream for*

storytelling (X3), Using Snapchat and Instagram for storytelling (X4), Using audience analytics to drive traffic and inform coverage (X5), Writing better headlines for mobile audiences (X6), Presenting stories better for mobile audiences (X7), Using data journalism to develop enterprise stories (X8), Creating simple graphics, such as maps and charts (X9), and telling stories using podcasts (X10). Each independent variable was rated by the participants from 1–5 points.

The *dependent (outcome) variable (Y)* presented the participants' learning needs; focused on learning needs related to smartphones (i.e., the smartphone skills that participants still desire to learn or need more knowledge). The dependent variable was formed by six sub-items, including the learning need of using smartphones (1) to shoot video, (2) to edit video, (3) to shoot photos, (4) to edit photos, (5) to record audio, and (6) to edit audio. Each of the six sub-items was rated by the participants from 1–5 points and the total Y score ranged from 6–30 points for each participant. **The purpose of the regression analysis was to investigate the correlation and effects between participants' perceived skills for their job requirements (*X*) and their actual perceived learning needs of digital skills with smartphones (*Y*).**

Results are shown in the following Table 1 (which is a revision of Table 2 in Study 2 provided in Appendix 2). Data provided in Table 1 shows the β-value with its standard error. The β-value is the degree of change in the dependent variable for every one-unit of change in the independent variable and the standard error means the standard deviation of the score distribution in each independent variable. Accordingly, under the premise of being statistically significant (i.e., the *p* value of the analysis results was

< .05), the higher β-value of an independent variable (*X*) was, the more impacts an

independent variable could provide to change the dependent variable (*Y*).

Table 1

Correlations and Effects between Mobile Journalists' Perceived Important Skills for Job

Requirements and Perceived Learning Needs by Groups

Independent Variables (Xs): Skills Needed for Journalism Job	**Dependent Variable (Y): Learning Needs with Smartphones**				
	All groups (*n* = 433)	Students (*n* = 27)	Educators (*n* = 64)	Professionals (*n* = 293)	MCM workers (*n* = 49)
Using social media for news reporting	.92 (.19)	**1.84 (.73)***	.81 (.40)*	**.93 (.26)***	.88 (.58)
Using social media for personal branding	.20 (.20)	.75 (.77)	.19 (.46)	.05 (.26)	.55 (.65)
Using Facebook Live stream for story telling	**.57 (.20)***	1.25 (.80)	.57 (.47)	.51 (.26)*	**1.75 (.71)***
Using Snapchat and Instagram for story telling	.33 (.19)	.03 (.80)	**1.12 (.48)***	.15 (.24)	.04 (.67)
Using audience analytics to drive traffic and inform coverage	.39 (.19)*	−.07 (.77)	.82 (.43)	.32 (.26)	.69 (.68)
Writing better headlines for mobile audiences	.51 (.23)*	1.72 (1.38)	.78 (.47)	.46 (.30)	1.31 (.73)
Presenting stories better for mobile audiences	.13 (.25)	.25 (1.20)	.16 (.58)	.20 (.33)	.67 (.81)
Using data journalism to develop enterprise stories	−.14 (.20)	−.29 (.81)	−.38 (.44)	−.05 (.28)	.12 (.52)
Creating simple graphics, such as maps and charts	.51 (.21)*	−1.08 (.89)	−.49 (.57)	.60 (.27)*	1.32 (.72)
Telling stories using podcasts	.92 (.17)	1.22 (.68)	.46 (.44)	1.04 (.22)	.89 (.62)
	F = 25.43* Inter. = 4.47 R^2 = .36	F = 3.98* Inter.= 6.14 R^2 = .31	F = 6.13* Inter. = 6.17 R^2 = .45	F = 15.54* Inter. = 4.53 R^2 = .33	F = 5.14* Inter. = 9.39 R^2 = .26

Note. Independent Variables (Xs) = skills of job requirements as reported by the participants. Dependent Variable (Y) = participants' learning needs of digital skills with smartphones. Data presented in the table = the β-value and its standard error (i.e., value of standard deviation in regression analysis). "*" = the *p* value < .05. The highest β-

values with statistical significance in each group were bold. Inter. = the intercept. R^2 (standardized R square) = the degree of explaining the variance in the dependent variable.

Results show that participants' learning needs with smartphones was significantly correlated to some of the ten job requirements across all groups and the skill of *using Facebook Live stream for story telling* had the highest β-value with statistical significance (β = . 57) among the ten independent variables. It means, that *using Facebook Live stream for story telling* for journalism job requirements is the most important skill for all groups and all groups think they need to learn more how to use smartphones for Facebook Live streaming. In addition, different groups of MoJos have different learning needs. For example, in the Educator group says that *Snapchat and Instagram for storytelling* is an important journalism job requirement (highest statistical significant β-value, β = 1.12, *p* < .05) and that they need to learn more about how to use those tools. The groups of students and journalism professionals perceive the use of *social media for news reporting* as the most important skill for the journalism job (i.e., this variable had the highest significant β-value), and they have a need to learn how to use the smartphone for this usage. As for the MCM workers group, the job requirement skill of *using Facebook Live stream for story telling* was the most important skill that correlates with the MCM workers' needs to learn how to use the smartphone for Facebook Livestream.

Lastly, the study found that participants' learning needs had a high correlation with their willingness to spend time on learning with mobile micro lessons; half of the participants (50 %) were willing to spend four to eight minutes per day on learning a digital skill and one-fifth of participants (20%) were willing to spend two to four minutes per day on learning.

Implication

According to the results, three key points were identified for mobile journalism educators and practitioners. First, it was noteworthy to know that even experienced journalists require continuous learning of digital and mobile skills with smartphones. Second, digital skills such as writing better news headlines and stories for mobile audiences were the most on-demand learning needs. Third, the mobile-based short-length learning format was acceptable by journalists because it could fit into their busy work schedules and flexibly meet their needs to obtain required knowledge and skills just in time.

Conclusion

Mobile microlearning was identified as a promising solution to support journalists' on-demand learning in this study. Future research was suggested to further investigate which MML design principles were useful for MoJos' knowledge and skills acquisition and then to examine the effects of MML designs on MoJos' learning efficacy and learner experiences. This conclusion led to the third and fourth studies: to design, develop, and assess a MML system for supporting MoJos' just-in-time digital skills learning with smartphones.

Study 3: Iterative Usability Testing: Formative Evaluation of a Mobile Microlearning Course

Study Goal (Problem Statement)

In the systematic literature review of MML in Study 1, two exploration gaps were identified. First, the review results observed that several mobile apps and platforms had been developed and applied in the MML approach, but a specific mobile microcourse

targeting the needs of MoJos was still lacking. Second, literature showed that instructional designers tended to focus on the design and creation of bite-size learning contents and activities, but the investigation of learners' experiences interacting with MML platforms and potential usability issues were neglected (Chai-Arayalert & Puttinaovarat, 2020; Kumar & Goundar, 2019; Rensing, 2016). To fill the gaps, this study (Study 3) aimed to develop a MML course for supporting MoJos' on-demand learning and conduct usability testing for this developed mobile microcourse in order to identify potential user experience and usability problems before applying to the real-world practice. The entire study is presented in Appendix 3.

Theoretical Background

The theory of *usability* has a standardized definition as "the extent to which a product can be used by specified users to achieve specified goals with *effectiveness*, *efficiency*, and *satisfaction* in a specified context of use" (ISO, 1998, Part II 9241-11 standard; Sauro & Lewis, 2016). The main concept of designing MML consists of two codependent elements, the digital technology and the instructional method (Lee et al., 2021). Accordingly, the technical and pedagogical usability heuristics (Nielsen, 1994; Nokelainen, 2006) are essential criteria to apply in designing and conducting usability evaluation for a specific MML platform. Aligned with the proposed theory of *usability* for designing the MML, three main usability components of *effectiveness, efficiency,* and *satisfaction* and two critical usability evaluation heuristics of technical and pedagogical usability criteria were used as a foundation to support the entire usability testing.

Methods

In the *design* phase of a mobile microcourse, a set of design principles of MML synthesized in previous work (Jahnke et al., 2020) were used to guide the course design and development. A high-fidelity prototype was created, named "The 5 Cs of writing news for mobile audiences" and supported by a mobile learning application (EdApp). The learning objective of this mobile microcourse was decided to focus on MoJos' capability building in writing news headlines and stories for mobile audiences, according to MoJos' learning needs of digital skills identified in Study 2. The detailed design sequence and instructional flows of the mobile microcourse are shown in Appendix 3 and Appendix 4. Examples and screenshots of the 5Cs are presented in Appendix 5.

In the *usability testing* phase, a formative usability research approach (Nielsen, 1993) was applied with three sequential iteration cycles (two stages of expert reviews and one stage of end-user usability test) to evaluate the design of the 5Cs mobile microcourse. Data records included participants' responses, perceptions, and comments during the test. Quantitative data (i.e., closed questions with Likert scales) were analyzed by SPSS statistics software and presented in descriptive statistics (Park, 2009) and qualitative data (i.e., open-ended questions) were analyzed using the content analysis method (Mayring, 2004). Final results were generalized into concrete improvement recommendations with relevant screenshots as examples, and then the developed 5Cs mobile microcourse was refined in each iteration cycle. The detailed execution procedure and testing methods are presented in Appendix 3.

Main Results (answer to RQ2)

Overall, the participants perceived effective, efficient, and satisfied with the mobile microcourse. In terms of the results in each iteration cycle, in Iteration 1, four

technical usability problems such as the *minimalism in design issue* for mobile interfaces (e.g., overlapping texts) and the *consistency issue* (e.g., inconsistent font type), and one pedagogical issue of *feedback presentation* to learners were initially identified by two experts with improvement recommendations. In Iteration 2, one minor technical issue of *visibility of the system status* and two pedagogical issues to *create values* and *applicability for learning* were addressed by another two experts. In Iteration 3, 12 usability issues were addressed by the users and their testing observers, including six technical issues (e.g., *error prevention, minimalism in design*) and six pedagogical problems (e.g., *learner control, learning activity and feedback*) (see Table 5 of paper #3 in Appendix 3). Lastly, when comparing the results across the three-iterative cycles, this study found that experts and the users not only identify common usability issues but also proposed different perspectives on certain design problems. Take the design of learning content as an example. Expert concerned with the difficulty level of learning materials which were too easy to master a person's professional skills while the users perceived the time to read learning instructions and the time on completing the activities were too short. Different perspectives of the MML designs were revealed when including both the experts and end-users in this study. More detailed descriptions of the results are shown in Appendix 3.

Implication

Aligned with the three-cycle iterative usability testing for the developed MML course, this study proposed three reflective points which could be insights for future user experience and usability researchers and practitioners. First, the design of meaningful learning contents into small screens mobile platforms was a challenge in the MML

42

approach. Several problems of the *minimalism in design* for small screens were identified such as the problem of inconsistent font type and overlapping texts on the screen. Second, it was notable that, though the mobile microcourse had been designed according to a set of MML design principles (Jahnke et al., 2020), many technical and pedagogical usability issues were still identified in this iterative usability testing. This result referred to the necessity of usability research for the process of designing learning with technologies as it could reveal potential interface and interaction design problems of the learning platforms. Lastly, although experts and the users evaluated the same learning platform, they expressed different perspectives and concerns about the design. Experts tended to focus on what things look like on the screen (interface design) and users mostly targeted problems on their interactions with these designs (interaction design). This blended usability method to include both experts and the end-users in the evaluation stage could help with the exploration from diverse points of view, and therefore, this approach was recommended for future usability studies.

Conclusion

In the design and development process of this 5Cs mobile microcourse, usability testing was an important factor to identify potential user experience and usability issues that could not be observed by the educators or instructors. With the iterative stages of usability testing, many technical and pedagogical design problems of the mobile microcourse were identified and the designs were improved, accordingly. The final refinement of the 5Cs mobile microcourse was completed and moved to the next study for an examination of its effects on MoJos' LX and learning efficacy.

Study 4: Mobile Microcourse Design and Effects on Learning Efficacy and Learner Experience

Study Goal (Problem Statement)

Literature review in Study 1 showed that there was a lack of evidence-based results to support the assumption that MML can be a promising approach to support MoJos' knowledge structure, skills development, or foster their positive learner experiences. To fill this gap, a developed 5Cs mobile microcourse was ready for the examination. This study (Study 4) aimed to examine the designs and effects of the developed 5Cs mobile microcourse on MoJos' learning efficacy and learner experiences. The full article is included in Appendix 4.

Theoretical Background

The study adopted a conceptual framework of Honebein and Honebein (2015) who differentiate the three outcome values of instructional designs as *effectiveness, efficiency,* and *appeal*. The three components were constructed for the concept of learning efficacy and applied as the main foundation and measurement objectives for assessing Mojos' learning growth and learner experiences with the 5Cs mobile microcourse. In the dissertation, effectiveness was defined as a measure of learners' learning achievement; efficiency was understood as a measure of learners' time and/or cost on their learning process; and appeal was conceptualized as a measure of continued learner participation (i.e., is the learner willing to continuously learn with the learning materials?).

Methods

The study was conducted in a formative research approach (McKenney & Reeves, 2018) to iteratively test the LX and learning efficacy. The learning intervention was conducted with 35 journalists by a set of pre-and-posttests and before- and after-course surveys. The before-course survey consisted of eight question items regarding basic demographic information such as gender, position in the professional field, years of work experience, perceptions about personal skills, and existing knowledge about writing news for mobile audiences. The after-course survey included 11 questions regarding participants' perceptions and experiences after learning with the mobile course. The pre- and posttests measured participants' learning growth (La Barge 2007) and the hypothesis f was that the knowledge level would be relatively higher after the course. The pre- and posttests had the same ten multiple-choice questions. Questions #1 to #9 were asking the participants to select a best headline from two options and the correct answer of each question was the headline that led to at least a doubling in readers of a story on a major metropolitan newspaper's website. Question #10, "Which technique can be applied to chunk news stories?" was a four-options multiple-choice question. See the pre- and posttests items in Appendix 5. During the intervention, participants downloaded the EdApp to their personal smartphones and had eight days to complete all the microlessons, tests, and surveys on this app. Participants could use the app whenever they had time, even just five minutes, to complete a micro-session. For the data analysis, quantitative data such as participants' pre-and post-test scores (i.e., gained score before and after learning with the mobile microcourse) and closed question survey responses (e.g., Likert scales) were analyzed by statistical methods and qualitative data such as open-ended

45

survey responses was analyzed with a thematic analysis method (Benesty et al. 2009; Park 2009).

Main Results (answer to RQ3)

The study showed that the 5Cs mobile microcourse was efficient and appealing to learners and positively affected learning effectiveness by increasing learners' knowledge about writing news for mobile audiences. Results of learning efficiency showed that participants' average time spent on each lesson was 4.7 minutes (ranged from 4.4 to 4.9 minutes) and 86% of the participants said that each microlesson's length was about right. For the result of learning effectiveness, 80% of participants obtained higher test scores after completing the course, 8.57% of participants received the same scores, and 11.42% of participants got lower scores after completing the lessons. In terms of the result of the appeal of the MML course, all 35 participants agreed that they would recommend the course to other learners who were in the field of journalism and 86% of the participants perceived the course was convenient to fit the short lessons into their daily routine. Lastly, this study identified the importance of a four-step sequence for the design of MML lessons, including (a) an aha moment, (b) interactive content, (c) short gamified exercises, and (d) instant feedback. In a nutshell, Study 4 provided evidence-based results to infer that such a mobile microcourse designed in the format of the four-step sequence could efficiently support MoJos' learning. In addition, the designs of timed gamified exercises, automated feedback, and interactive real-world content indicated rooms for improvements to enhance learning effectiveness.

Implication

Two takeaway points were addressed from the fourth study. First, the results showed that the MML design met its goals for supporting efficient and appealing content to learners, however, the room remained to improve its learning effectiveness as the developed mobile microcourse was not equally effective for all learners. Future research was needed to explore how to improve the design of MML to equally fulfill the outcome values of learning effectiveness, efficiency, and appeal. Second, for practitioners and educators who intended to use MML as a medium to enhance learning efficacy, it was useful to apply the four specific design principles of instructional flow in a rather small and nugget-size format, including (a) an aha moment, (b) interactive content, (c) short gamified exercises, and (d) instant automated feedback when designing skill-based learning units such as computer programming, business marketing, and video editing.

Conclusion

Study 4 not only provided evidence-based results to support the statement that MML could efficiently and effectively improve MoJos' knowledge structure and positive LX but also identified four feasible design principles which could be applied for the MML development. But this study remained spaces for improvements in terms of the MML design for learning effectiveness, and it was suggested for future MML research to be conscious of this limitation and further, explore potential design solutions to improve learning effectiveness.

Ethical Considerations of the Research

In agreement with the values addressed in Bell and Bryman (2007), five essential ethical considerations of the dissertation are addressed as follows:

First, participants in every research stage of the dissertation were not subjected to harm in any ways whatsoever and they had the right to withdraw from the research without the exercise of any pressure or coercion at any stage if they wished to do so.

Second, the dissertation did obtain execution approval from the MU Campus Institutional Review Board (IRB) and obtained full consent from the participants before conducting the research. The informed consent involved sufficient information, including the goal of the research, the purpose of the data usage, the level of potential harms in the research, and the demonstration of participants' personal privacy and security regarding their proposed information.

Third, this dissertation ensured an adequate level of confidentiality of the research data and avoided the use of offensive, discriminatory, and other unacceptable languages in the formulation of any measurements such as surveys, observations, and interviews.

Fourth, this dissertation ensured the anonymity of individuals participating in the research and took participants' privacy into consideration.

Fifth, each study in this four-article dissertation (one study developed as one paper) that recruited participants had requested the IRB exemption.

Chapter 4: Discussion and Conclusion

In this chapter, the first section discusses results of this research work from different theoretical and practical perspectives. The second section adds implications and recommendations to existing knowledge for future research and practices. Lastly, the third section addresses research limitations and the conclusion of this dissertation.

Discussion

In the discussion section, six topics are addressed to highlight the novel knowledge that has been created in this dissertation.

First, in the literature, Wenger et al. (2014) and Wenger et al. (2018) had initially synthesized the most popular digital skills required by the top 10 journalism companies in the 21st century and provided a set of digital skills to guide for MoJos' professional development, but they did not specify which skills were the most urgent needs perceived by mobile journalists (MoJos). This dissertation viewed Wenger et al. (2014) and Wenger et al.'s (2018) research results as a cornerstone for investigating journalists' learning needs of digital-mobile skills and contributed to the knowledge they had developed by applying their synthesized digital skill set as variables to further predict the most important skills that MoJos perceived they need in this research. Study 2 of the dissertation indicated that there were four different types of MoJos: journalism students, educators, journalism professionals, and mass communication and media workers. Results showed that all four groups reported high demands on continuously developing their digital skills and perceived the most urgent need was to develop the skill of using smartphones to create news headlines and present stories for mobile audiences. Moreover, results in Study 2 of the dissertation found that the four different groups of

MoJos had their own learning priorities for acquiring specific digital skills. For instance, (a) journalism educators' first priority was to master the skill of using Snapchat and Instagram for storytelling, (b) mass communication and media workers had high-demands on developing the skill of using Facebook Live stream function for storytelling, and (c) journalism students and professionals wanted to first enhance the skill of using social media for mobile news reporting. These findings contribute to the journalism academic community to obtain a clear understanding of MoJos' learning needs.

Second, Study 4 showed that the MML design positively supported the three outcome values of learning effectiveness, efficiency, and appeal. However, when looking specifically into the effect of these three outcomes compared to efficiency and appeal, the design for learning effectiveness has rooms for improvements as the results showed that the MML design in this research was not equally effective for all learners; 30.48 % learners did not meet the minimum required scores of their learning growth in Study 4. This result reflects the statement reported in Honebein and Honebein's (2015) study. They found that one of the outcome values tended to be traded-off or sacrificed when educators designed a curriculum or learning material. Examples of the sacrifice patterns of these three values are that useful methods for cognitive content could sacrifice appeal, useful methods for attractive content could sacrifice efficiency, and useful methods for interpersonal content could sacrifice learning effectiveness (Honebein & Honebein, 2015). Honebein and Honebein (2015) suggested to allocate more time in the design process to prioritize the learning contents. If efficiency and appeal continue to be the favored outcome of this mobile microcourse, further research is needed to put the effort into investigating how greater effectiveness can be achieved.

50

Third, in terms of the measurement outcome of learning effectiveness, this dissertation mainly used the 10 multiple choice questions in Study 4 to ask the learners to choose a better news headline from paired options (Appendix 5). In the test, learners need to *recall* what they have learnt from the 5Cs' mobile microcourse and *compare* and *identify* a better news headline from the given options. From a critical point of view, this type of text-based multiple choice questions can only assess learners' lower-order thinking skills of Bloom's Taxonomy such as *remembering* (i.e., retrieving relevant knowledge from long-term memory) and *understanding* (i.e., determining the meaning of instructional messages) (Krathwohl, 2002). However, it is hard to understand whether the MML course can really support or improve learners' higher-order thinking skills such as *synthesizing* information, *generalizing* or *transferring* ideas across contexts, *evaluating* and *critiquing* a specific situations, or *creating* and *designing* a new plan or project (Brookhart, 2010; Churches, 2009; Krathwohl, 2002). Therefore, applying the text-based multiple choice questions to assess learning effectiveness in this MML research has its pitfall as it cannot comprehensively assess learners' abilities of using higher-order thinking skills to solve problems or deal with specific situations. Bring and Lyon (2019) suggest that simulation-based learning or role-play technique can be a useful format to support learners achieve complex learning outcomes. Aligned with this idea, simulation-based learning may be a potential solution for the MML approach to cultivate a learners' complex learning outcomes. For example, future research can redesign the learning measurement by developing a short video with a simulation scenario such as an upcoming event and then asking MoJos to create a mobile news headline for mobile newsreaders within 30 seconds. To complete this task, it would require both lower-and

higher-order thinking skills, including the abilities of *identifying* spotlight messages from the video, *synthesizing* the messages into a short burst and understandable text-based presentation format, and *creating* a news headline for this simulation scenario. Further research is needed to examine how to develop an effective MML measurement mechanism by including the assessment of both lower-and higher-order thinking skills and to investigate.

Fourth, the insights about the measurement of learning effectiveness take the discussion to a broader consideration of what MML can and cannot do. What kind of learning can MML really support? In this dissertation, the design of MML can deliver pocket-size knowledge and information which allows the learners to easily absorb and quickly apply to their work practices. But these pocket-size knowledge in the MML approach are defined in a fairly convergent, fixed, and determinate way. For example, a specific 5Cs technique to write a news headline for mobile newsreaders. MML has its limitation to provide a more complex, or advanced skills training because of its short and just-in-time design format. The design of MML in this research can only give a single and short piece of directions or instructions for each technique but cannot immediately deliver instructions for a multi-skills execution to help learners succeed in more complex tasks. For instance, in journalism education, it is difficult to deliver a bit-size lesson to immediately teach a journalist a comprehensive skill set of creating a virtual reality (VR)-based storytelling pieces on smartphones. Developing a VR-based storytelling pieces is technically complex–it encompasses a range of several actions and techniques, including the skills of photo shooting using many camaras from diverse angles, 3D scenes development using computer programing, motion graphic design, interaction design, user

experience and usability evaluation, etc. (Mabrook & Singer, 2019). Complex learning usually takes time, and sometimes it happens unexpectedly weeks, months, or even years to become a master (Knight & Banks, 2003). This research addresses the limitation of MML to cultivate complex learning outcomes, and yet it still shows its potential in this research results to support a person's just-in-time and goal-oriented learning needs in the context of mobile journalism education. Future research can take this advantage of the MML approach to extend its implementation into different learning contexts (i.e., formal, nonformal, informal, and blended learning environments), and meanwhile blending with different learning methods such as stimulation-based or problem-based learning activities and assessments to compensate MML's limitation.

Fifth, by adopting the framework of the sociotechnical-pedagogical learner experience (LX), this dissertation contributes to an interconnected framework that extends traditionally narrow views of HCI and Learning Design & Technology (LDT) toward a more comprehensive view: LX design is more than just a user-centered UX design that it not only focuses on user interaction but also includes *learning* and the learner's experience with the pedagogical elements such as learning goals, learning activities, assessments, and other learning designs. In this formative research (McKenney & Reeves, 2018), an iterative usability approach (Nielsen, 1993) was applied from the user-centered UX field to study technological and pedagogical usability issues of this developed MML course (Study 3). The results of this usability study provided information about learners' perceptions on the ease of use of the learning platform and their ideas about the contents and tasks which could be supported in their learning process. However, these findings were insufficient for this dissertation to understand or

improve a positive LX; which means studying whether the learner *learned,* i.e., if there was an increased knowledge growth aligned with the learning goals of the MML course design. To fill the gap, this dissertation adopted the research structure to include both the assessment of LX and learning efficacy of the MML course design in Study 4 (see Figure 5 in this dissertation, the Phase 4 of the user-centered design process). Due to the integration of traditional user-centered UX concepts with LX design which includes the measurement of a positive LX and learning efficacy, the combination of UX and LX lens in this research work can be called *an advanced format*. Aligned with this advanced format, the dissertation provides evidence-based results reflecting Jahnke et al.'s (2020) statement that LX is more than UX and states the standpoint that LX research is an emerging paradigm in the crossroads of HCI and LDT.

When looking deeper into the three dimensions of the technological, pedagogical and social dimension for understanding MoJos' LX with MML, the design for the social dimension is relatively sacrificed in this research. The social dimension emphasizes the interaction among learners by means of technological tools as well as the development of a supportive community of learners (Jahnke et al., 2020). But in this dissertation, the goal was to support MoJos to quickly absorb on-demand digital skills with their smartphones and then allowed them to use these skills just-in-time to solve specific problems from their work. Accordingly, this MML design was focused on self-paced learning with bite-size unit contents and thus the design for social-oriented interactions and collaborations between learners, teachers, and peers was rather absent in this research work. Jonassen and Rohrer-Murphy (1999) argue that "learning most naturally occurs not in isolation but by teams of people working together to solve problems" (p.70) and put stress on the

principle of designing conversation and collaboration tools for constructing active

learning environments. Informed by this statement, it is suggested to target the social

dimension and develop human-human interaction mechanisms on the MML platform.

Practical examples would include having teachers add a few minutes of video

introductions at the beginning of the MML course, to build an asynchronous Q&A space

that learners can request answers for their questions whenever they need and teachers and

peers can give feedback at any time at their convenience, and to set up a sharing and

discussion community platform that after the course learners are able to share their work

or examples relevant to the learning topic through the website or social media links

(Jahnke et al., 2020). Besides, further research is needed to examine whether increasing

the designs of the social dimension in the MML approach is suitable for mobile

journalism education and how these designs can be fit into MoJos' just-in-time learning

format.

Lastly, this dissertation contributes to the emergent field of LX Design &

Research (Schmidt et al., 2020). As presented in the Theoretical Framework section in

Chapter 2, the LX definition and framework by Schmidt et al. (2020) and Jahnke, Riedel,

Singh, and Moore (2021) is a promising start. However, Jahnke and her colleagues have

not provided further descriptions regarding whether this definition can be applied in a

specific learning context (e.g., formal, informal, non-formal education) or indicated its

best fit in a certain set of situations, MML for example. Whether their definition is

appropriate guidance to apply in the MML approach leaves an uncertainty. With the

results addressed in this dissertation and informed by the adult learning theory (Knowles,

1980), this research suggests refining the LX definition by Jahnke et al. (2021) for the field of MML in the following direction:

> Learning experience (LX) of MML encompasses all aspects of a learner's interaction with (a) the small screen of mobile technologies, especially smartphones; (b) the short and focused burst pedagogical components, such as courses that are no more than five minutes, goal-oriented learning objectives, game-based activities, hands-on exercises, problem-based assessments, and self-directed learning pace control; and (c) the social dimension, such as instant and personalized feedback on learners' activity performance or exercise outcomes, a just-in-time communication box for peers and instructors, and a chunk size collaborative workspace for learners to work together or share professional information.

Implications for Future Research

First, from the perspective of the pedagogical dimension of the LX framework, results in the dissertation indicated that the MML design (example of the 5Cs mobile microcourse) not only positively affected Mojos' learning efficiency and appeal but also supported their knowledge growth (i.e., remembering the concepts of the 5Cs writing skills and understanding how to apply the concepts to write mobile news headlines or stories). From a critical point of view, although this gamified MML design with the micro-exercises can foster learners' click activities that support a quick absorption of information, it is difficult to know whether the click activities can construct learners' deeper skills such as critical thinking, for example, judging the credibility of source or information or developing and defending a position on an issue (Ennis, 1993). Since

"learners who are able to think critically are able to solve problems effectively" (Snyder & Snyder, 2008, p. 90), further research is required to study how to design critical thinking exercises and assessments for MML to effectively cultivate such advanced skills.

Second, from the perspective of the social dimension of the LX framework, literature has shown that learning is more effective in an active and collaborative format than in passive and non-collaborative conditions (Deslauriers, McCarty, Miller, Callaghan, & Kestin, 2019; Fakomogbon & Bolaji, 2017). The MML design in this dissertation meets the concept of active learning (Michael, 2006) which allows learners to activate their learning through activities that force them to reflect upon ideas and concepts and to apply those concepts into real-practices (e.g., MoJos engaged in short exercises to learn how to use the 5Cs to write a mobile-friendly news headline), but this MML design lacks a collaborative learning environment for learners to expand and solidify their learning with other journalism professionals in a broader context. Future research is suggested to equally develop both active and collaborative learning environments and to examine how this type of design positively affects LXs in the MML context.

Third, from the perspective of the technological dimension of the LX framework, it is critical to include end-users as a part of the course development process when conducting a learner-centered design (Love, 2005). The iterative usability testing (Study 3) in the research verifies this statement. Results showed that although experts and users identified the same issue on the mobile microcourse, their target points and perspectives were different. For example, experts and the users both indicated font size issues, but the

57

experts identified the need of making the font size consistent while the users addressed the need for a bigger font size in order to easily read contents on a small screen. The research found that experts' viewpoints tended to focus on problems relating to the interface design; what things looked like such as the visual styling of fonts, page layouts, graphic images, buttons, and navigation menus. Users' experiences and perceptions mostly concerned issues on interaction design; how they interacted with those specific design elements, and how the designs affected their actions to achieve their needs and goals. Hence, this dissertation concludes that a mixed usability evaluation to combine an expert review method and end-user usability testing is a feasible approach to explore potential usability issues comprehensively from diverse angles.

Lastly, from the standpoints of human-computer interaction and learning, design, and technology, developing learning content with mobile technologies is not an easy task because of the limitation of small screen size (Kumar & Goundar, 2019; Jahnke et al., 2020). The dissertation reveals this concern in Study 3. Several problems related to the design for small screens were identified in the research. For example, the design of a scrolling bar was annoying when space was not enough to fit in all the materials, and, the design of adding several texts and images at once on the mobile screen made learners visually overwhelmed. Kumar and Goundar (2019) state that visual representations such as icons, pictures, sound, text, and background colors may greatly assist in the user learning process, but they also argue that careful usage of these components is necessary because it may be difficult in optimizing, visualizing and manipulating these elements into small screen mobile technologies. The approach of MML design does not support the same amount of elements that are used in learning management systems developed for

desktop or laptop use. It would be helpful to further investigate how to condense the contents into small screen smartphones but still deliver meaningful learning information for learners as well as how much contents are appropriate for efficient MML.

Recommendations for Practice

From a practical application approach, this dissertation gives new knowledge on how to design MML courses to support learning experiences and increase their efficiency, effectiveness, and appeal by four sequential design principles, including design for an aha moment, interactive content, short gamified exercises, and instant automated feedback.

According to the results of the four-article dissertation, the following takeaway points of designing for MML are based on what the research considers most noteworthy:

First, this dissertation suggests that when applying short exercises in MML design, it is critical to be aware of the time learners spend on these tasks. In this developed mobile microcourse, many short exercises were designed with a time limit such as dragging and dropping to add missing words in 30 seconds. But the research found that the time span of the exercise design was too short that learners felt frustrated and did not have enough time to understand the instruction and complete the gamified tasks. This issue might affect LXs and cause counterproductive learning outcomes. Thus, it is suggested that learning designers, instructional developers, and educators in the field assess appropriate time spent on short exercises when designing MML.

Second, a new knowledge referring to the design of automated instant feedback is suggested within the dissertation. Results in this research indicated that learners wanted personalized feedback instead of having only the correct answers with standard

explanations so that they were able to understand the gap between what they already learned and where to improve. In the 5Cs mobile microcourse, the automated feedback system worked well when there was only one correct answer. But when learners interacted with an open-ended exercise such as writing a news headline, the feedback system could only provide one correct headline and explain why it was correct. This type of feedback could not comment on a learner's particular work and advise how it could be better. Accordingly, to design a meaningful feedback system in MML, it is suggested that the design of automated feedback includes more personalized and differentiated comments, instead of generalized automated feedback.

Third, this dissertation assumes that the four sequential design principles for MML can be applied to other fields beyond the context of mobile journalism. For example, in medical education, a design of simulated mobile-based micro exercises for situated topics such as seizures is suggested for improving medical students' professional knowledge and skills acquisition and supporting their LXs.

Lastly, a set of MML design recommendations can be synthesized from this dissertation study as a guide to develop a useful and efficient microlearning system on small screens of mobile devices for improving learner experiences. Table 2 shows the design recommendations in the technological dimension (system design), the pedagogical dimension (learning design), and the social dimension (technology-mediated human-human interaction design) of MML as well as the description of an instructional flow of each single MML design.

60

Table 2

MML Design Recommendations Developed From this Dissertation

Technological Dimension–System Design of MML.

Key principle: Be short, explicit, concise, and readable.
- The font should be consistent and font size should be no more than two types on a small screen.
- The number of text-based sentences should be no more than three at once on a small screen.
- Redundant texts and irrelevant images should be removed because too much elements on a small screen can make learners visually overwhelmed.
- The navigation path and course instructions should be simple and concise.
- The margins and line spacings of each design element and every page should have enough space and be consistent in order to avoid overlapping elements when the screen size is too small.
- No scrolling bar on the small screen is suggested since it can occupy the space for displaying important content and scrolling actions can increase the time learners browse the materials and decrease the learning efficiency.

Pedagogical Dimension–Learning Design of MML.

Key principle: Be chunked, interactive, visualized, and relatedness.
- The learning content should be presented by only one single concept or topic at once on a mobile screen.
- The course length should be between 30 seconds to five minutes per unit.
- The learning materials should be presented in multiple formats, for examples, short text instructions, aha moment images, gamified exercises and quizzes (e.g., timed true or false, drag-n-drop answer responses), text-based multiple choices, chatting box, and bite-size review of lessons.
- Timed exercises should be tested by target learners/users to ensure the time length of the exercises are about right (not be too short or too long).
- Examples in the MML are better to be connected to the real world practices so that learners can quickly link their life experiences and previous knowledge to the current learning topics.
- Feedback should be automated, instant, and personalized aligned with each learners' learning actions and performances.
- The instructional flow of each single MML unit: Providing an *aha moment* simulation or scenario followed by the objective, examples, and concluding with a call for action *interactive exercises* and *immediate feedback*.

Social Dimension–Human-Human Interaction Design of MML.

Key principle: Be flexible, supportive, communicative, and responsible.
- Build an asynchronous Q&A space for learners, peers and teachers.
- Set up a sharing and discussion community platform.

In sum, instructional designers, educators, and system developers in the field of MML in particular, and LDT in general, receive here specific design guidelines for MML, a guide on how to apply "research to improve" (Honebein & Reigeluth, 2021), and can make more informed decisions regarding the quality of micro-content developments on small screens of mobile devices. Furthermore, in workplace training, this dissertation provides guidelines for the industry on how to design self-paced micro-trainings to facilitate employees' workplace learning or performances. Lastly, the MML designs in this research can be used as best or good practice for the journalism industry.

Limitations

This dissertation focuses on the approach of MML and how MML design supports mobile journalists' learning. Limitations of the research may include the application of the four MML design principles. This dissertation used the four design principles specifically in the context of mobile journalism education. Here, another research in a different learning field such as medical education or business education may be helpful in understanding whether the four design principles are feasible and generalizable to other learning contexts.

Moreover, in the past years, learning has been conceptualized as constructivism where educators understand learning as that the students actively construct knowledge in a situated context rather than passively receive and transmit knowledge from the instructors. MML, however, uses a learning approach based on the paradigm of behaviorism–learner clicks on interactive content. This approach is useful for specific learning goals such as learning how to use the 5Cs concepts. To advance MML, critical studies of MML could explore concepts of how MML designs can go beyond the clicking

approach and demonstrate the learning efficacy of MML from diverse paradigms such as the human cognitive development perspective (Cerratto-Pargman & Jahnke 2019; Lv et al., 2019).

Conclusion

This dissertation applied the educational design research approach (McKenney & Reeves, 2018) with an advanced sociotechnical-pedagogical integrated user-and learner-experience framework that provided evidence-based insights on mobile microlearning, and contributed to a new body of knowledge in the design and development of MML in the context of journalism education. Future research on MML can consider the specific design principles proposed in the dissertation and apply the concept to a broader audience or other professional fields such as team management for engineers or knowledge construction and conceptualization in medical education and clinical practices.

References

Al Jazeera Media Training & Development Center. (2017). *Mobile Journalism.*
https://institute.aljazeera.net/sites/default/files/2018/mobile%20journalisn%20english.pdf

Alade, T., Welch, R., Robinson, A., & Nichol, L. (2020, March). Mobile Learning for
Just-In-Time Knowledge Acquisition in a Workplace Environment. In *2020 3rd
International Conference on Information and Computer Technologies
(ICICT)* (pp. 198-204). IEEE.

Althobaiti, M. M., & Mayhew, P. (2016). Users' Awareness of Visible Security Design
Flaws. *International Journal of Innovation, Management and Technology*, *7*(3),
96-100.

Bano, M., Zowghi, D., Kearney, M., Schuck, S., & Aubusson, P. (2018). Mobile learning
for science and mathematics school education: A systematic review of empirical
evidence. *Computers & Education*, *121*, 30-58.

Barnes, C. (2012). Citizen journalism vs. traditional journalism: A case for
collaboration. *Caribbean Quarterly*, *58*(2-3), 16-27.

Bell, E., & Bryman, A. (2007). The ethics of management research: An exploratory
content analysis. *British Journal of Management, 18*(1), 63-77.

Benesty, J., Chen, J., Huang, Y., & Cohen, I. (2009). Pearson correlation coefficient.
In *Noise reduction in speech processing* (pp. 1-4). Springer, Berlin, Heidelberg.

Bowen, K., Forssell, K., & Rosier, S. (2020). Theories of Change in Learning Experience
(LX) Design. In M. Schmidt, A. A. Tawfik, I. Jahnke, & Y. Earnshaw (Eds.),

Learner and User Experience Research: An Introduction for the Field of Learning Design & Technology. EdTech Books. https://edtechbooks.org/ux/lx

Brandenburg, D. C., & Ellinger, A. D. (2003). The future: Just-in-time learning expectations and potential implications for human resource development. *Advances in developing human resources*, *5*(3), 308-320.

Bring, A., & Lyon, S. W. (2019). Role-play simulations as an aid to achieve complex learning outcomes in hydrological science. *Hydrology and Earth System Sciences, 23*(5), 2369-2378.

Brookhart, S. M. (2010). *How to assess higher-order thinking skills in your classroom.* ASCD.

Bui, M. N., & Moran, R. E. (2020). Making the 21st century mobile journalist: Examining definitions and conceptualizations of mobility and mobile journalism within journalism education. *Digital Journalism*, *8*(1), 145-163.

Burum, I., & Quinn, S. (2015). *MOJO: The mobile journalism handbook: How to make broadcast videos with an iPhone or iPad*. CRC Press.

Pargman, T. C., & Jahnke, I. (Eds.). (2019). *Emergent practices and material conditions in learning and teaching with technologies*. Springer.

Cervi, L., Pérez Tornero, J. M., & Tejedor, S. (2020). The challenge of teaching mobile journalism through MOOCs: A case study. *Sustainability*, *12*(13), 5307-5322.

Chai-Arayalert, S., & Puttinaovarat, S. (2020). Designing Mangrove Ecology Self-Learning Application Based on a Micro-Learning Approach. *International Journal of Emerging Technologies in Learning (iJET)*, *15*(11), 29-41.

Churches, A. (2009). Bloom's digital taxonomy.

http://burtonslifelearning.pbworks.com/f/BloomDigitalTaxonomy2001.pdf

Costello, J., & Oliver, J. (2018). Human Resource Management in the Media. *Costello, J. and Oliver, JJ (2018). Human Resource Management in the Media. Handbook of Media Management and Economics (Media Management and Economics Series)*, 95-110.

Dabbagh, N., Marra, R. M., & Howland, J. L. (2018). *Meaningful online learning: Integrating strategies, activities, and learning technologies for effective designs*. Routledge.

De Troyer, O., Maushagen, J., Lindberg, R., & Breckx, D. (2020). Playful Learning with a Location-Based Digital Card Environment: A Promising Tool for Informal, Non-Formal, and Formal Learning. *Information, 11*(3), 157-184.

Deslauriers, L., McCarty, L. S., Miller, K., Callaghan, K., & Kestin, G. (2019). Measuring actual learning versus feeling of learning in response to being actively engaged in the classroom. *Proceedings of the National Academy of Sciences*, *116*(39), 19251-19257.

Deuze, M. (1999). Journalism and the Web: An analysis of skills and standards in an online environment. *Gazette (Leiden, Netherlands)*, *61*(5), 373-390.

Dingler, T., Weber, D., Pielot, M., Cooper, J., Chang, C. C., & Henze, N. (2017, September). Language learning on-the-go: opportune moments and design of mobile microlearning sessions. In *Proceedings of the 19th International Conference on Human-Computer Interaction with Mobile Devices and Services* (pp. 1-12).

Emerson, L. C., & Berge, Z. L. (2018). Microlearning: Knowledge management
applications and competency-based training in the workplace. *Knowledge Management & E-Learning, 10*(2), 125-132.

Ennis, R. H. (1993). Critical thinking assessment. *Theory into practice*, *32*(3), 179-186.

Epp, C. D., & Phirangee, K. (2019). Exploring mobile tool integration: Design activities
carefully or students may not learn. *Contemporary Educational Psychology, 59*, 101791-101807.

Fakomogbon, M. A., & Bolaji, H. O. (2017). Effects of collaborative learning styles on
performance of students in a ubiquitous collaborative mobile learning environment. *Contemporary Educational Technology*, *8*(3), 268-279.

Glass, Gene V. (1976). Primary, Secondary, and Meta-analysis of Research. *Educational Researcher, 5*(10), 3-8.

Good, A., & Omisade, O. (2019). Linking Activity Theory with User Centred Design: A
Human Computer Interaction Framework for the Design and Evaluation of. *Applied Interdisciplinary Theory in Health Informatics: A Knowledge Base for Practitioners*, *263*, 49-63.

Göschlberger, B., & Bruck, P. A. (2017, December). Gamification in mobile and
workplace integrated microlearning. In *Proceedings of the 19th International Conference on Information Integration and Web-based Applications & Services* (pp. 545-552).

Graneheim, U. H., Lindgren, B. M., & Lundman, B. (2017). Methodological challenges
in qualitative content analysis: A discussion paper. *Nurse education today*, *56*, 29-34.

Grant, M. M. (2019). Difficulties in defining mobile learning: Analysis, design characteristics, and implications. *Educational Technology Research and Development, 67*(2), 361-388.

Gray, C. M. (2020). Paradigms of Knowledge Production in Human-Computer Interaction: Towards a Framing for Learner Experience (LX) Design. In M. Schmidt, A. A. Tawfik, I. Jahnke, & Y. Earnshaw (Eds.), Learner and User Experience Research: An Introduction for the Field of Learning Design & Technology. EdTech Books. https://edtechbooks.org/ux/paradigms_in_hci

Hansen, W. J. (1972, May). User engineering principles for interactive systems. *Proceedings of the fall joint computer conference* (pp. 523-532).

Hanshaw, G., & Hanson, J. (2018). A mixed methods study of leaders' perceptions of microlearning for professional development on the job. *International Journal of Learning and Development*, *8*(3), 1-21.

Harte, R., Glynn, L., Rodríguez-Molinero, A., Baker, P. M., Scharf, T., Quinlan, L. R., & ÓLaighin, G. (2017). A human-centered design methodology to enhance the usability, human factors, and user experience of connected health systems: a three-phase methodology. *JMIR human factors, 4*(1), e8.

Hautasaari, A., Hamada, T., Ishiyama, K., & Fukushima, S. (2019). VocaBura: A Method for Supporting Second Language Vocabulary Learning While Walking. Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies, 3(4), 1-23.

Hermida (2010). From TV to Twitter- How ambient news became ambient journalism.

Media/Culture Journal, 13(2). https://journal.media-
culture.org.au/index.php/mcjournal/article/view/220/0

Hollingsed, T., & Novick, D. G. (2007, October). Usability inspection methods after 15
years of research and practice. In *Proceedings of the 25th annual ACM
international conference on Design of communication* (pp. 249-255).

Honebein, P. C., & Reigeluth, C. M. (2021). To prove or improve, that is the question:
the resurgence of comparative, confounded research between 2010 and
2019. *Educational Technology Research and Development*, 1-32.

Honebein, P. C., & Honebein, C. H. (2015). Effectiveness, efficiency, and appeal: pick
any two? The influence of learning domains and learning outcomes on designer
judgments of useful instructional methods. *Educational Technology Research and
Development*, *63*(6), 937-955.

Hudson, L., Amponsah, C., Bampoe, J. O., Marshall, J., Owusu, N. A. V., Hussein, K., ...
& McNaney, R. (2020, April). Co-designing Digital Tools to Enhance Speech and
Language Therapy Training in Ghana. Proceedings of the 2020 CHI Conference
on Human Factors in Computing Systems (pp. 1-13).

Huo, C., & Shen, B. (2015). Teaching reform of English listening and speaking in China
based on mobile micro-learning. Creative Education, 6(20), 2221-2226.

International Organization for Standardization. (2010). *ISO 9241-210:2010 Ergonomics
of Human-System Interaction–Part 210: Human-Centred Design for Interactive
Systems.* https://www.iso.org/standard/52075.html

ISO (1998). 9241-11. Ergonomic Requirements for Office Work with Visual Display

Terminals (VDTs). Part 11: Guidance on Usability.

https://www.iso.org/standard/16883.html

Jahnke, I., Lee, Y. M., Pham, M., He, H., & Austin, L. (2020). Unpacking the inherent

design principles of mobile microlearning. *Technology, Knowledge and Learning,*

25(3), 585-619.

Jahnke, I. (2015). *Digital didactical designs: Teaching and learning in*

CrossActionSpaces. Routledge.

Jahnke, I., Riedel, N., Singh, K., & Moore, J. (accepted 2021, February 14). Advancing

sociotechnical-pedagogical heuristics for the usability evaluation of online courses

for adult learners*. Online Learning Journal.*

Jahnke, I., Schmidt, M., Pham, M., & Singh, K. (2020). Sociotechnical-Pedagogical

Usability for Designing and Evaluating Learner Experience in Technology-

Enhanced Environments. In M. Schmidt, A. A. Tawfik, I. Jahnke, & Y. Earnshaw

(Eds.), *Learner and User Experience Research: An Introduction for the Field of*

Learning Design & Technology. EdTech Books.

https://edtechbooks.org/ux/sociotechnical_pedagogical_usability

Jonassen, D. H., & Rohrer-Murphy, L. (1999). Activity theory as a framework for

designing constructivist learning environments. *Educational technology research*

and development, *47*(1), 61-79.

Kadhem, H. (2017, October). Using mobile-based micro-learning to enhance students;

retention of IT concepts and skills. In 2017 2nd International Conference on

Knowledge Engineering and Applications (ICKEA) (pp. 128-132). IEEE.

Karhunen, P. (2017). Closer to the story? Accessibility and mobile journalism. *Reuters Institute for the Study of Journalism.* University of Oxford.

Kim, G. J. (2015). *Human-computer interaction: fundamentals and practice.* CRC press.

Kitsa, M. (2019). Smartphones in journalism. *Media Literacy and Academic Research*, *2*(2), 94-108.

Knight, P. T., & Banks, W. M. (2003). The assessment of complex learning outcomes. *Global journal of engineering education, 7*(1), 39-50.

Knowles, M. S. (1980). The modern practice of adult education: From pedagogy to andragogy (revised and updated). *Englewood Cliffs, NJ: Cambridge Adult Education*. Cambridge.

Kolodzy, J. (2013). *Practicing convergence journalism: An introduction to cross-media storytelling.* Routledge.

Krathwohl, D. R. (2002). A revision of Bloom's taxonomy: An overview. *Theory into practice, 41*(4), 212-218.

Kumar, B. A., & Goundar, M. S. (2019). Usability heuristics for mobile learning applications. *Education and Information Technologies*, *24*(2), 1819-1833.

Lee, Y. M., Jahnke, I., & Austin, L. (2021). Mobile microlearning design and effects on learning efficacy and learner experience. *Educational Technology Research and Development*, 1-31.

Love, S. (2005). *Understanding mobile human-computer interaction.* Elsevier.

Lv, M., Liu, H., Zhou, W., & Zheng, C. (2019). Efficiency model of micro-course study based on cognitive psychology in the college. *Computers in Human Behavior*, 106027-106036.

Mabrook, R., & Singer, J. B. (2019). Virtual reality, 360 video, and journalism studies: conceptual approaches to immersive technologies. *Journalism Studies, 20*(14), 2096–2112.

Maniou, T. A., Stark, A., & Touwen, C. J. (2020). Journalism Training Beyond Journalism Schools. *Journalism & Mass Communication Educator*, *75*(1), 33-39.

Manuti, A., Pastore, S., Scardigno, A. F., Giancaspro, M. L., & Morciano, D. (2015). Formal and informal learning in the workplace: a research review. *International journal of training and development, 19*(1), 1-17.

Mayring, P. (2004). Qualitative content analysis. *A Companion to Qualitative Research, 1,* 159-176.

McAuley, L., Tugwell, P., & Moher, D. (2000). Does the inclusion of grey literature influence estimates of intervention effectiveness reported in meta-analyses?. *The Lancet, 356*(9237), 1228-1231.

McKenney, S., & Reeves, T. (2018). *Conducting educational design research.* New York: Routledge.

Michael, J. (2006). Where's the evidence that active learning works?. *Advances in physiology education, 30,* 159-167.

Nelson, L. J., Cushion, C. J., & Potrac, P. (2006). Formal, nonformal and informal coach learning: A holistic conceptualisation. *International Journal of Sports Science & Coaching*, *1*(3), 247-259.

Nielsen, J. (1993). Iterative user-interface design. *Computer*, *26*(11), 32-41.

Nielsen, J. (1994, April). Usability inspection methods. In *Conference companion on Human factors in computing systems* (pp. 413-414).

Nikou, S. A., & Economides, A. A. (2018). Mobile-Based micro-Learning and

Assessment: Impact on learning performance and motivation of high school

students. *Journal of Computer Assisted Learning, 34*(3), 269-278.

Nokelainen, P. (2006). An empirical assessment of pedagogical usability criteria for

digital learning material with elementary school students. *Journal of Educational

Technology & Society*, *9*(2), 178-197.

Norman, D. A. & Draper, S. W. (Editors) (1986). *User-Centered System Design: New

Perspectives on Human-Computer Interaction.* Lawrence Earlbaum Associates.

Norman, D. A., & Spohrer, J. C. (1996). Learner-centered education. *Communications of

the ACM*, *39*(4), 24-27.

Norsanto, D., & Rosmansyah, Y. (2018, March). Gamified mobile micro-learning

framework: A case study of civil service management learning. In *2018

International Conference on Information and Communications Technology

(ICOIACT)* (pp. 146-151). IEEE.

Ohkawa, Y., Kodama, M., Konno, Y., Zhao, X., & Mitsuishi, T. (2018, May). A study on

UI design of smartphone app for continuous blended language learning. *In 2018

5th International Conference on Business and Industrial Research (ICBIR)* (pp.

584-589). IEEE.

ONeill, K., Robb, M., Kennedy, R., Bhattacharya, A., Dominici, N. R., & Murphy, A.

(2018). Mobile technology, just-in-time learning and gamification: Innovative

strategies for a CAUTI education program. *On-Line Journal of Nursing

Informatics, 22*(2). http://www.himss.org/ojni

Ormrod, J. E. (2011). *Human learning.* Pearson Higher Ed.

Örnebring, H. (2013). Anything you can do, I can do better? Professional journalists on

    citizen journalism in six European countries. *International Communication*

    Gazette, *75*(1), 35-53.

Park, M. H. (2009). *Comparing Group Means: T-tests and One-Way ANOVA Using*

    Stata, SAs, R, and SPSS. Centre for Statistical and Mathematical Computing,

    Indiana University. https://scholarworks.iu.edu/dspace/handle/2022/19735.

Peng, D. (2017, July). On Platform Construction of English Vocabulary Learning in

    Higher Vocational Colleges Based on Mobile Micro Learning. In *2017 9th*

    International Economics, Management and Education Technology Conference

    (IEMETC 2017) (pp. 513-516). Atlantis Press.

Pham, XL, & Chen, GD (2019). PACARD: A New interface to increase mobile learning

    app engagement, distributed through App Stores. *Journal of Educational*

    Computing Research , 57 (3), 618-645.

Reigeluth, C. M., & Carr-Chellman, A. A. (Eds.). (2009). *Instructional-design theories*

    and models, volume III: Building a common knowledge base (Vol. 3). Routledge.

Rensing, C. (2016, July). A context aware learning application for communities of

    service technicians. *In 2016 IEEE 16th International Conference on Advanced*

    Learning Technologies (ICALT) (pp. 77-81). IEEE.

Riffe, D., Lacy, S., Fico, F., & Watson, B. (2019). *Analyzing media messages: Using*

    quantitative content analysis in research. Routledge.

Salzmann, A., Guribye, F., & Gynnild, A. (2020). "We in the Mojo Community"–

    Exploring a Global Network of Mobile Journalists. *Journalism Practice*, 1-18.

Sauro, J., & Lewis, J. R. (2016). *Quantifying the user experience: Practical statistics for user research.* Morgan Kaufmann.

Schmidt, M., Earnshaw, Y., Tawfik, A. A., & Jahnke, I. (2020). Methods of User Centered Design and Evaluation for Learning Designers. In M. Schmidt, A. A. Tawfik, I. Jahnke, & Y. Earnshaw (Eds.), *Learner and User Experience Research: An Introduction for the Field of Learning Design & Technology.* EdTech Books. https://edtechbooks.org/ux/ucd_methods_for_lx

Shail, M. S. (2019). Using micro-learning on mobile applications to increase knowledge retention and work performance: A review of literature. *Cureus, 11*(8): e5307.

Simons, L. P., Foerster, F., Bruck, P. A., Motiwalla, L., & Jonker, C. M. (2015). Microlearning mApp Raises Health Competence: Hybrid Service Design. *Health and Technology, 5*(1), 35-43.

Snyder, L. G., & Snyder, M. J. (2008). Teaching critical thinking and problem solving skills. *The Journal of Research in Business Education, 50*(2), 90-99.

Sun, G., Cui, T., Dong, F., Xu, D., Shen, J., Chen, S., & Lin, J. (2018, July). (WIP) Evaluation of a Cloud-Based System for Delivering Adaptive Micro Open Education Resource to Fresh Learners. *In 2018 IEEE 11th International Conference on Cloud Computing (CLOUD)* (pp. 586-589). IEEE.

Umair, S. (2016). Mobile reporting and journalism for media trends, news transmission and its authenticity. *Journal of Mass Communication and Journalism*, *6*, 323-328.

Višňovský, J., & Radošinská, J. (2017). Online journalism: Current trends and challenges. *The Evolution of Media Communication.* IntechOpen.

Wang, R., Chen, L., Solheim, I., Schulz, T., & Ayesh, A. (2017, March). Conceptual
motivation modeling for students with dyslexia for enhanced assistive learning. In
*Proceedings of the 2017 ACM Workshop on Intelligent Interfaces for Ubiquitous
and Smart Learning* (pp. 11-18).

Wenger, D., Owens, L., & Thompson, P. (2014). Help wanted: Mobile journalism skills
required by top US news companies. *Electronic News*, *8*(2), 138-149.

Wenger, D. H., Owens, L. C., & Cain, J. (2018). Help wanted: Realigning journalism
educa- tion to meet the needs of top US news companies. *Journalism & Mass
Communication Educator*, *73*(1), 18-36.

Westlund, O., & Quinn, S. (2018). Mobile journalism and MoJos. In *Oxford research
encyclo- pedia of communication*. Oxford University Press.

Wurmser, Y. (2019) *US Time Spent with mobile 2019.*
https://www.emarketer.com/content/us-time-spent-with-mobile-2019

Xiao, Y., & Watson, M. (2019). Guidance on conducting a systematic literature review.
Journal of Planning Education and Research, 39(1), 93-112.

Zurita, G., Baloian, N., Peñafiel, S., & Jerez, O. (2019). Applying Pedagogical Usability
for Designing a Mobile Learning Application that Support Reading
Comprehension. In *Multidisciplinary Digital Publishing Institute Proceedings*
(Vol. 31, No. 1, p. 6-21).

Appendix 1–Paper 1: Mobile Microlearning: A Systematic Literature Review and Implications

Paper 1: submitted to the *Journal of Interactive Learning Environment (ILE).*

Mobile Microlearning: A Systematic Literature Review and Implications

The study aimed to conduct a systematic literature review to identify the trends, impacts, and challenges of mobile microlearning (MML) research. Using five academic databases from the fields of social science, engineering, and medical science as search sources, 26 scholarly articles, published between 2015 and 2020, were retrieved. The study applied a content analysis method to analyze and synthesize the data with three focal points: (a) research purposes and publication sources; (b) research settings, including learning domains, contexts, research methods, measures, and participants; and (c) research outcomes, advantages, and challenges of MML based on the reviewed literature. Results indicated that the mixed-method approach has become a trend in MML studies and MML has been widely applied in both formal and informal settings, especially in the just-in-time workplace learning. In terms of advantages, MML not only enhanced learners' achievement and motivation but also improved skills and knowledge retention. Some deficiencies of MML that were identified included the need for further investigation on meaningful designs of microcontents to fit into small screen mobile devices and issues of usability. The paper discusses implications for researchers and practitioners.

Keywords: mobile microlearning; systematic literature review; workplace training; just-in-time learning; informal education

Introduction

Literature shows people learn better and more effectively when learning in small steps with the content broken down into digestible small pieces (Shail, 2019). From a cognitive load theory perspective, too much information showing at once on a small screen can increase people's mental fatigue. That mental fatigue can cause serious cognitive decline in an individual's performance because of the limited cognitive processing capacity in a persons' working (short-term) memory (Shail, 2019). Therefore, microlearning argues for dividing the content into small and focused units and designing the content for the small screen size of mobile devices (Cates, Barron,

Ruddiman, 2017), and accordingly, mobile microlearning has emerged as a bridge between the two concepts of mobile learning and microlearning.

Mobile microlearning (MML) is defined as a series of bite-size instructions, with average lessons ranging from 90 seconds to five minutes, that are created purposely to facilitate learning at any pace and at any time with mobile devices (Jahnke et al., 2020; Zheng et al., 2019). MML is derived from the two concepts of microlearning and mobile learning, and literature synthesizes the two domains into a new learning approach called mobile microlearning.

Before 2012, scholars used the concept of *microlearning* with *mobile devices* or *mobile learning* with *microcontents* to address the domain of mobile microlearning (Beaudin & Intille, 2006; Kovachev et al., 2011). After 2012, the term *mobile microlearning* (MML) become widely applied in several learning fields (Butgereit, 2016; Edge et al., 2012). Although several educational contexts have applied MML as a medium for diverse learning situations such as the improvement of high school students' science learning (Nikou & Economides, 2018), literature does not clearly explain how to efficiently design an appropriate MML course. This study acknowledges that Jahnke and her colleagues (2020) have conducted a review of MML on academic research articles and industry reports published between 2013 and 2019 and have synthesized 15 design principles of MML regarding pedagogical usability issues and sequenced instructional flows.

However, understanding MML design principles may be not sufficient to provide a comprehensive picture of what learning topics have been conducted throughout MML research, what kinds of methodologies have been applied to structure the MML studies, how MML is implemented in learning settings, and how MML impacts learner experiences. Hence, to ensure researchers and practitioners can remain

up to date in their understanding of MML and its impacts on learning, this study aimed to conduct a Systematic Literature Review (SLR) to map the trends and issues of MML research and practices.

To analyze the existing literature of mobile microlearning studies, the main research questions (RQs) were as follows.

- **RQ1:** What are the general characteristics, including research purposes and the source and year of publications, reported in MML studies?

- **RQ2:** What are the research settings, including learning domains, learning platforms, and supported learning technologies, applied in MML studies?

- **RQ3:** What are the research outcomes of learner experiences, advantages, and challenges of MML as identified in MML studies?

Methodology

Aiming at mapping the mobile microlearning research and implementations in the existing literature, scholarly articles published between 2015 and 2020 were selected for a Systematic Literature Review (SLR) (Xiao & Watson, 2019). Guided by Xiao & Watson's (2019) systematic literature review structure, the study addressed search strategy, article selection criteria, article selection procedure, and data extraction, synthesis and analysis as follows.

Search strategy: databases and search keywords

Google Scholar, ERIC, PubMed, ProQuest, and IEEE Xplore were used to check to be sure all MML studies were comprehensively collected. The last search was completed on December 15, 2020. Five sets of keywords were applied as search terms:

"mobile microlearning," "mobile micro-learning," "mobile-based microlearning," "Microlearning" AND "smartphones", and "micro-learning" AND "smartphones".

Article selection criteria

The study identified inclusion and exclusion criteria as follows according to the study goal.

Inclusion Criteria

- Articles must involve both concepts of "microlearning" and "mobile learning."
- Learning technologies applied in the MML studies must be smartphones or mobile phones. (tablets and iPads were excluded).
- Articles must be published in peer-reviewed scholarly conference proceedings and or academic journals

Exclusion Criteria

- Articles written in a language other than English were excluded.
- Book chapters, textbooks, handbooks, reports, dissertations, study proposals, discussion forums, trade magazines, etc. were excluded.
- Articles only available in abstract (i.e., lacking full text) were not included.

Article selection procedure

The articles selection process consisted of five steps: initial search and identification (Step 1); screening (Step 2); eligibility (Step 3); quality assessment (Step 4); and final article selection (Step 5) (see Figure 1). A quality assessment (Bano et al, 2018) was conducted in Step 4 to ensure the systematic literature review answered the proposed research questions. To be included in this study, articles found by the SLR had to meet

all four of the criteria listed below:

- The study provided sufficient details of research objectives.

- Participants' characteristics were described clearly.

- Information about the research settings were described in the study.

- Study outcomes were described in the study.

The quality assessment determined six articles did not meet the criteria. The six papers were removed from the qualified pool. A total of 26 articles qualified to move on to Step 5 and each article was given a study-ID (S-ID) for later analysis (see Table 1).

Data extraction

Seven targeted attributes were identified as data extraction criteria (see Table 2). For the basic information, the extraction data included the article title, author(s), country of the study, the type and name of publication source (e.g., journal or conference), publication year, and impacts of the articles, meaning the impact factors of its source, CImago journal rankings, SJR, and Google Scholar citations.

Data synthesis and analysis

This study applied a quantitative content analysis method with a combination of deductive and inductive strategy (Graneheim, Lindgren, & Lundman, 2017; Riffe, Lacy, Fico, & Watson, 2019) aiming to identify the frequencies that each attribute occurred as well as to analyze the study patterns of the 26 selected articles. An assistant software of data analysis, Atlas.ti 8, was used to code and organize the extracted data. The data analysis and synthesis process followed six phases, as shown in Table 3.

A deductive strategy was used in the data extraction stage with the concept-driven coding that applied six identified criteria (Table 2) as a coding guidance to retrieve the data from an abstract level to concrete and specific counted values (Boman

et al., 2015; Graneheim et al., 2017). An inductive strategy was used in the data analysis

and synthesis stage to group the similar attributes into the same categories and a

common theme was created for each category (Sırakaya & Alsancak Sırakaya, 2020).

Results

RQ1: Overview of general characteristics of MML studies

An overview of the 26 selected studies are shown in Figure 2. The inclusion criteria of

the systematic literature review only selected articles reported in English. However, the

analysis shows the 26 studies have been conducted around the world in diverse cultural

contexts. Studies in Europe, Africa, and Asia initially reported the research of MML in

2015, and the United States and Canada have been interested and joined the MML

research in 2017. In terms of the publication outlet, the qualified articles were dispersed

among different sources, including 15 peer-reviewed journals and 11 conference

proceedings, and included diverse fields, such as human computer interactions (HCI),

medical science, business, and information, communication, and learning technologies,

(see Appendix 2).

Publications sources and impacts of MML studies

To understand the impact selected articles made in the academic research community,

the study checked the journal impact factor, SCImago journal ranking, and the Google

Scholar citation count (see Appendix 2). Results showed the impact factor (IF) ranged

from 0.41 to 3.14. The *Journal of ACM Transactions on Computer-Human Interaction*

identified from S16 and the *Journal of Vaccine* in the field of medical science identified

from S9 had the highest impact factors (IF=3.14). An engineering education study

conducted by S26 in the *Journal of IEEE Transactions on Education* (IF=2.27) had the

most counts of citations in Google Scholar (65 citation counts) followed by Nikou &

Economides' (2018) study of science education (S14) in the *Journal of Computer Assisted Learning* (54 citation counts). It is interesting to note that the most impactful articles of MML studies were presented in the field of science and engineering education.

Research purposes of MML studies

Results show that the majority of the selected articles (80.76%) aim to examine whether an MML approach can enhance learner experiences and learning performance, including studies targeted on employees' professional skills, a person's language capacity building, and a person's learning motivation, engagement, and knowledge and skills retention (see Table 4). There were additional focuses described in some of the articles. One target was on how a particular MML platform could support lifelong learning (e.g., Chai-Arayalert & Puttinaovarat, 2020; De Troyer et al., 2020). Others focused on the promotion of health-related knowledge and behaviour (e.g., Dale et al., 2019; Simons et al., 2015).

RQ2: Research settings of MML studies

Learning domains

Table 5 shows the most common focus of the MML studies was second language learning (e.g., Epp & Phirangee, 2019), which included 30.77% of the studies, followed by employees' workplace training (e.g., Norsanto & Rosmansyah, 2018) which included 19.23% of the studies. Some MML research focused on the topic of engineering education (e.g., Sun et al., 2018), science education (e.g., Wang et al., 2017), and healthcare knowledge building (e.g., Simons et al., 2015). Specific learning subjects, such as liberal education (e.g., De Troyer et al., 2020), ecology education (e.g.,

Chai-Arayalert & Puttinaovarat, 2020), nursing education (e.g., ONeill et al., 2018), and social science (e.g., Hudson et al., 2020), were also examined in previous MML studies.

Learning contexts

The results presented in Table 5 also indicate four types of learning contexts: formal (30.77%), informal (46.15%), nonformal (15.38), and blended learning environment (7.69%). Formal educational settings are defined as traditional school-based environments where learning follows structured timeframes and planned activities for specific subjects, such as high school science classrooms (e.g., Nikou & Economides, 2018). Informal educational settings can occur anytime and anywhere in our daily life as well as during critical moments when an individual gains knowledge, skills, and problem-based solutions in practice due to an immediate need (e.g., Göschlberger & Bruck, 2017). Nonformal settings are conceptualized as any systematic educational activities intended to deliver specific learning content for a particular population, such as workshops (e.g., Simons et al., 2015). Finally, blended settings consist of any combination of formal, informal, and nonformal situations (e.g., Jahnke et. al, 2020; Shail, 2019). In addition, it is notable that more than half of the studies (18 out of 26) utilized self-developed mobile platforms (apps) to investigate the effectiveness of MML studies (See Table 5).

Types of participants

In terms of the types of participants, the majority of MML articles (73.08%) were found to be conducted among the adult population (frequency of count, $f = 19/26$) in workplace training, language learning, and higher engineering education. Mixed-age participant populations appeared in 15.38% of the articles ($f = 4$) whereas 11.54% of the articles had a sample of only young people (middle and high school students) as study

participants ($f = 3$). Notably, young people were mostly applied in the science education research, and the mixed age group was mostly applied in an informal setting and in diverse learning domains, such as healthcare knowledge building, and liberal arts education (e.g. social science). The interpretation of information presented in Table 5 is describe below:

$$(Study\ ID)\ {}^{Type\ of\ learning\ platform:\ (1)self-dev.\ (2)\ self-dev.game\ (3)exi.app\ (4)NA}_{Type\ of\ study\ participant:\ (1)adult\ (2)young\ (3)mix.age}$$

Type of learning platform consists of (1) the application of a self-developed mobile app (self-dev.), (2) self-developed game-based mobile app (self-dev.game), (3) existing mobile app created by a third party (exi.app), and (4) no report in the article (NA). Type of study participants consists of adult learners, young learners, and mixed age groups (mix.age). For examples, $(S14)\ _{young}^{self-dev.}$ means the study used a self-developed mobile app for young learners.

Study approaches and measures of MML research

The included set of articles consisted of three study approaches: quantitative, qualitative, and mixed methods. Table 6 shows 65.38% of studies were conducted with the quantitative research approach. Results also shows further classifications of measurement methods under each approach as they were addressed by the authors in selected articles. The most common instruments used in MML studies were survey method (30.77%) followed by observations (15.38%) and interviews (11.54%). Besides the single measurement methods, mixed measurement tools also showed high frequency of use in the selected studies such as the blend of survey and interview methods applied in S2 and S13 (7.69%).

RQ3: Outcomes of learner experiences, advantages, and challenges of MML

Outcomes of learner experiences

Table 7 indicates that 76.92% of the studies have reported MML had positive impacts on learners' learning experiences. These articles showed the greatest benefits of MML for learners included the increase of their engagement, motivation, and interest, as well as the fulfillment of their learning needs. However, 15.38% of the studies proposed that the impact of MML could vary for learners in different situations. For instance, Epp and Phirangee (2019) found that how effective MML was depends on learners' characteristics and needs. For example, only the just-in-time learners and the person who is used to using the mobile app experienced positive effects on their learning. Sun et al. (2018) also addressed the concept that interface and interaction designs of mobile learning systems were important factors on how learners' learning experiences were affected.

Advantages and deficiencies of MML as identified in MML studies

The selected studies highlighted numerous advantages of MML. Some of the challenges related to its implementation were also observed (see Table 8).

The most frequently noted advantage of MML was that the learning approach could go beyond the school setting and provided learners a flexible learning environment in diverse conditions (e.g., De Troyer et al., 2020; Hautasaari et al., 2019). For example, employees can learn skills just in time during their daily work routines and apply those learned skills in specific contexts (e.g., Hudson et al., 2020; ONeill et al., 2018). MML was able to facilitate information processing and reduce learners' mental fatigue during the learning process because the content was divided into small pieces which were easily absorbed (e.g., Epp & Phirangee, 2019; Kadhem, 2017).

Table 8 also shows that up to 50% of the selected articles did not provide specific statements regarding deficiencies of MML. The other half of the selected studies pointed out diverse challenges of MML research. The most concerning issue of MML (19.50%) was a lack of user experience and usability test for the learning platforms. For instance, S2 explained that a lack of guidance to design meaningful learning content specifically for small screens was a limitation of MML. There was a need to further examine learner experiences on MML platforms to ensure interaction designs were easy to use for the mobile microlearning process.

Discussion

Implications for future research

A systematic literature review synthesizing the 26 selected studies presented several important implications. In general, the quantitative approach was the most frequently used research method in the selected studies before 2019 while the mixed-method approach, which included interviews along with the quantitative method, has become a trend in recent years.

In terms of the main purpose of MML research, the results revealed that selected studies not only applied MML to increase students' performance, achievement, learning motivation, and engagement but also to enhance employees' professional skills and knowledge retention. From a learning efficacy perspective, the goal to provide meaningful learning should consist of three outcome values: learning effectiveness (learning achievement and performance), learning efficiency (the time spent on learning), and appeal of learning contents to learners (learners' interests to learn) (Honebein & Honebein, 2015; Reigeluth & Carr-Chellman, 2009). It is noteworthy that the research purposes identified in selected articles tend to focus more on investigating

the learning effectiveness and appeal of learning contents in different settings than on learning efficiency. It is suggested that future MML research equally develop and examine all three components of effectiveness, efficiency, and the appeal of learning contents.

It is notable that more than half of the studies utilized self-developed mobile platforms (apps) to investigate the effectiveness of MML studies. It would be helpful for future research to further investigate the reasons behind this trend. In addition, assessing usability issues of MML platforms were reported as a problem in the selected studies, especially the challenge of presenting microcontents in a meaningful way to support the learning process. These concerns parallel the statements of Kabir and Kadage (2017) and Jahnke et al. (2020). Both of the studies indicated that since the amount of information to be displayed on small screens of mobile devices, especially smartphones, is limited due to the interface dimensions, a critical eye is needed on the MML designs to ensure the microcontents can be delivered effectively on the small-screen platforms. Furthermore, many of the selected studies involved adults and mixed-age learners as participants in MML research. The design of MML for blended age groups can be different from the traditional education setting, which is designed for a single-aged learning population. It is important that future research further investigate how to design and deliver a suitable microcourse on small-screen smartphones to fulfill the needs of diverse learning groups participating in MML.

Lastly, it is interesting to note that a half of the selected articles did not provide specific statements of MML challenges and the other half highlighted important issues associated with MML, such as insufficient learning content to cultivate learners' higher order thinking skills. To outline learners' learning patterns and provide sufficient contents, Hudson et al. (2020) proposed recommendations for improved collection of

metadata about learners' behaviors and preferences (e.g., machine learning, deep learning). Therefore, the newly understood learners' learning patterns allows educators or instructional designers of MML to better organize data log records, understand a specific learner's learning history, and be able to provide appropriate content options for specific learners (Hudson et al., 2020). Accordingly, it is necessary that there be more research specifically oriented toward combining MML with data science in the future.

Recommendations for practice

As for the learning domains and outcomes in selected studies, results indicated that MML provided versatile ways of learning, including a flash-card format for second language learning, a series of game-based design for professional skills development, an interactive location-based GPS design for liberal arts and ecology education, and quiz-based mini-exercises in engineering, science, medical, and nursing education. However, the outcomes reported in selected articles showed that not all aspects of learning were positively impacted by MML. The effects of MML depended on several factors, such as interface and interaction designs as well as learners' needs, characteristics, and knowledge structure. These results corroborate the findings of Jahnke et al., (2020). Jahnke et al., (2020) addressed that not only the instructional designs but also pedagogical usability issues, presentation sequenced flows for small-screen interfaces, and looks and tones of the learning systems need to be taken into considerations when designing MML.

Notably, the context of informal learning was widely applied in the selected studies of MML, such as the study of liberal arts education (e.g., De Troyer et al., 2020) and ecology education (e.g., Chai-Arayalert & Puttinaovarat, 2020), which went beyond school settings to promote lifelong learning. This observation was consistent with the trend reported by the other literature review study of Friedel, Bos, Lee, and Smith

(2013). Friedel et al. (2013) found that their selected articles emphasized smartphones with microcontents could facilitate learning both inside and outside of the physical classroom and that up to 80% of learners in one of the studies perceived smartphones as useful tools in their learning (Friedel et al., 2013). Because of the rapid development of 5G technologies and the ongoing COVID-19 pandemic, this nature of change impacts both personal learning as well as education across the global community (Daniel, 2020; Hodges et al., 2020). It is important for educators to be aware that informal settings become an essential trend applied in MML because people can learn remotely, synchronously, or asynchronously just in time when they need to, and without location restrictions.

Lastly, an important takeaway for educators was the contribution of MML to just-in-time learning in the workplace. Employees or workers with busy schedules could use their own smartphones to learn on-demand knowledge and skills with a bite-size lesson any time they needed to and immediately apply those learned skills into a specific context of practice (e.g., Hudson et al., 2020; ONeill et al., 2018). This advantage of just-in-time microlearning with smartphones could especially benefit the people who work outside in the field and have no time to join a long set of training courses, for example, mobile journalists, who need to gather and disseminate breaking news on the go and in a limited time frame.

Limitation of the study

Two limitations of the study were identified. First, the selected articles were limited to those written in English and the publication years were restricted to 2015 to 2020. There could be informative articles published in other languages and before 2015, which were not included in this review. Second, five academic databases were used to maximize the

search and article collection, but there may be overlooked relevant studies from other databases.

Conclusion

This study provides insight into how educators and researchers may conceptualize and facilitate MML. The results indicate that MML could not only increase students' performance, achievement, learning motivation, engagement, professional skills, and knowledge retention but also contribute to the field of just-in-time learning in the workplace so that employees can fit microlearning into their busy work routines anytime using their smartphones. Results also indicated that not all aspects of learning had positive effects and that the effects can depend on learners' needs, experiences, characteristics, and knowledge structure. It is suggested that educators take all relevant factors into consideration when designing MML..

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Declaration of interest statement

I declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

References

Bano, M., Zowghi, D., Kearney, M., Schuck, S., & Aubusson, P. (2018). Mobile learning for science and mathematics school education: A systematic review of empirical evidence. *Computers & Education*, *121*, 30–58. https://doi.org/10.1016/j.compedu.2018.02.006

Beaudin, J. S., & Intille, S. S. (2006). MicroLearning on a mobile device. *Proceedings of UbiComp 2006 Extended Abstracts (Demo Program)* (pp. 1–2). CiteSeerX. http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.65.7308

Berge, Z. L., & Muilenburg, L. (Eds.). (2013). *Handbook of mobile learning.* Routledge.

Boman, E., Häggblom, A., Lundman, B., Nygren, B., & Fischer, R. S. (2015). Inner Strength as Identified in Narratives of Elderly Women. *Advances in Nursing Science*, *38*(1), 7–19. doi: 10.1097/ANS.0000000000000057

Bruck, P. A., Motiwalla, L., & Foerster, F. (2012). Mobile Learning with Micro-content: A Framework and Evaluation. *Bled eConference, 25*, 527–543.

Butgereit, L. (2016, May). Gamifying mobile micro-learning for continuing education in a corporate IT environment. In *2016 IST-Africa Week Conference* (pp. 1–7). IEEE.

Carter, J. (2017). Expanding access to learning with mobile digital devices. *COABE Journal, 6*(2), 49–54.

Cates, S., Barron, D., & Ruddiman, P. (2017, September 4–7). MobiLearn go: mobile microlearning as an active, location-aware game. *Proceedings of the 19th International Conference on Human-Computer Interaction with Mobile Devices and Services* (pp. 1–7), Vienna, Austria.

Daniel, J. (2020). Education and the COVID-19 pandemic. *Prospects, 49*(1), 91–96. https://doi.org/10.1007/s11125-020-09464-3

Dessì, D., Fenu, G., Marras, M., & Recupero, D. R. (2019). Bridging learning analytics and cognitive computing for big data classification in micro-learning video collections. *Computers in Human Behavior, 92*, 468–477. https://doi.org/10.1016/j.chb.2018.03.004

Edge, D., Fitchett, S., Whitney, M., & Landay, J. (2012, September 21–24).

MemReflex: adaptive flashcards for mobile microlearning. *Proceedings of the 14th international conference on Human-computer interaction with mobile devices and services* (pp. 431–440), San Francisco, CA, USA.

Friedel, H., Bos, B., Lee, K., & Smith, S. (2013, March). The impact of mobile handheld digital devices on student learning: A literature review with meta-analysis. *In Society for Information Technology & Teacher Education International Conference* (pp. 3708–3717). Association for the Advancement of Computing in Education (AACE).

Graneheim, U. H., Lindgren, B. M., & Lundman, B. (2017). Methodological challenges in qualitative content analysis: A discussion paper. *Nurse education today*, *56*, 29–34. https://doi.org/10.1016/j.nedt.2017.06.002

Hodges, C., Moore, S., Lockee, B., Trust, T., & Bond, A. (2020). The difference between emergency remote teaching and online learning. *Educause review, 27*, 1–12.

Honebein, P. C., & Honebein, C. H. (2015). Effectiveness, efficiency, and appeal: pick any two? The influence of learning domains and learning outcomes on designer judgments of useful instructional methods. *Educational Technology Research and Development, 63*(6), 937–955. https://doi-org.proxy.mul.missouri.edu/10.1007/s11423-015-9396-3

Jahnke, I., Lee, Y. M., Pham, M., He, H., & Austin, L. (2020). Unpacking the inherent design principles of mobile microlearning. *Technology, Knowledge and Learning, 25*(3), 585–619. https://doi-org.proxy.mul.missouri.edu/10.1007/s10758-019-09413-w

Kabir, F. S., & Kadage, A. T. (2017). ICTs and educational development: The

utilization of mobile phones in distance education in Nigeria. *Turkish Online

Journal of Distance Education, 18*(1), 63–76. DOI: 10.17718/tojde.285716

Kovachev, D., Cao, Y., Klamma, R., & Jarke, M. (2011, December 8–10). Learn-as-

you-go: new ways of cloud-based micro-learning for the mobile web.

International conference on web-based learning (pp. 51–61). Hong Kong,

China.

Nikou, S. A., & Economides, A. A. (2018). Mobile-Based micro-Learning and

Assessment: Impact on learning performance and motivation of high school

students. *Journal of Computer Assisted Learning, 34*(3), 269–278.

https://doi.org/10.1111/jcal.12240

Reigeluth, C. M., & Carr-Chellman, A. A. (Eds.). (2009). *Instructional-design theories

and models, volume III: Building a common knowledge base* (Vol. 3).

Routledge.

Riffe, D., Lacy, S., Fico, F., & Watson, B. (2019). *Analyzing media messages: Using

quantitative content analysis in research*. Routledge.

Shail, M. S. (2019). Using micro-learning on mobile applications to increase knowledge

retention and work performance: A review of literature. *Cureus, 11*(8): e5307.

doi:10.7759/cureus.5307

Sırakaya, M., & Alsancak Sırakaya, D. (2020). Augmented reality in STEM education:

a systematic review. *Interactive Learning Environments*, 1–14.

https://doi.org/10.1080/10494820.2020.1722713

Traxler, J. (2009). Learning in a mobile age. *International Journal of Mobile and

Blended Learning (IJMBL), 1*(1), 1–12. DOI: 10.4018/jmbl.2009010101

Xiao, Y., & Watson, M. (2019). Guidance on conducting a systematic literature review. *Journal of Planning Education and Research, 39*(1), 93–112. https://doi.org/10.1177/0739456X17723971

Zheng, R., Zhu, J., Zhang, M., Liu, R., Wu, Q., & Yang, L. (2019). A novel resource deployment approach to mobile microlearning: from energy-saving perspective. *Wireless Communications and Mobile Computing, 2019*, 1–15. https://doi.org/10.1155/2019/7430860

Appendices

Appendix 1

Bibliographies of the final qualified articles (N=26) and their ID numbers

S-ID	Bibliography
S1	De Troyer, O., Maushagen, J., Lindberg, R., & Breckx, D. (2020). Playful Learning with a Location-Based Digital Card Environment: A Promising Tool for Informal, Non-Formal, and Formal Learning. Information, 11(3), 157–184.
S2	Chai-Arayalert, S., & Puttinaovarat, S. (2020). Designing Mangrove Ecology Self-Learning Application Based on a Micro-Learning Approach. International Journal of Emerging Technologies in Learning (iJET), 15(11), 29–41.
S3	Jahnke, I., Lee, Y. M., Pham, M., He, H., & Austin, L. (2020). Unpacking the inherent design principles of mobile microlearning. Technology, Knowledge and Learning, 25(3), 585–619.
S4	Hudson, L., Amponsah, C., Bampoe, J. O., Marshall, J., Owusu, N. A. V., Hussein, K., ... & McNaney, R. (2020, April). Co-designing Digital Tools to Enhance Speech and Language Therapy Training in Ghana. Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems (pp. 1–13).
S5	Epp, C. D., & Phirangee, K. (2019). Exploring mobile tool integration: Design activities carefully or students may not learn. Contemporary Educational Psychology, 59, 101791.
S6	Shail, M. S. (2019). Using micro-learning on mobile applications to increase knowledge retention and work performance: A review of literature. Cureus, 11(8): e5307.
S7	Pham, XL, & Chen, GD (2019). PACARD: A New interface to increase mobile learning app engagement, distributed through App Stores. Journal of Educational Computing Research, 57 (3), 618–645.
S8	Hautasaari, A., Hamada, T., Ishiyama, K., & Fukushima, S. (2019). VocaBura: A Method for Supporting Second Language Vocabulary Learning While Walking. Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies, 3(4), 1–23.
S9	Dale, L. P., White, L., Mitchell, M., & Faulkner, G. (2019). Smartphone app uses loyalty point incentives and push notifications to encourage influenza vaccine uptake. Vaccine, 37(32), 4594–4600.
S10	Norsanto, D., & Rosmansyah, Y. (2018, March). Gamified mobile micro-learning framework: A case study of civil service management learning. In 2018 International Conference on Information and Communications Technology (ICOIACT) (pp. 146–151). IEEE.
S11	Ohkawa, Y., Kodama, M., Konno, Y., Zhao, X., & Mitsuishi, T. (2018, May). A study on UI design of smartphone app for continuous blended language learning. In 2018 5th International Conference on Business and Industrial Research (ICBIR) (pp. 584–589). IEEE.
S12	Sun, G., Cui, T., Dong, F., Xu, D., Shen, J., Chen, S., & Lin, J. (2018, July). (WIP) Evaluation of a Cloud-Based System for Delivering Adaptive Micro Open Education Resource to Fresh Learners. In 2018 IEEE 11th International Conference on Cloud Computing (CLOUD) (pp. 586–589). IEEE.

S13	Hanshaw, G., & Hanson, J. (2018). A Mixed Methods Study of Leaders' Perceptions of Microlearning for Professional Development on the Job. International Journal of Learning and Development, 8(3), 1–21.
S14	Nikou, S. A., & Economides, A. A. (2018). Mobile-Based micro-Learning and Assessment: Impact on learning performance and motivation of high school students. Journal of Computer Assisted Learning, 34(3), 269–278.
S15	ONeill, K., Robb, M., Kennedy, R., Bhattacharya, A., Dominici, N. R., & Murphy, A. (2018). Mobile technology, just-in-time learning and gamification: Innovative strategies for a CAUTI education program. *On-Line Journal of Nursing Informatics, 22*(2). Retrieved from https://search.proquest.com/scholarly-journals/mobile-technology-just-time-learning-gamification/docview/2132298424/se-2?accountid=12719
S16	Cai, C. J., Ren, A., & Miller, R. C. (2017). WaitSuite: Productive use of diverse waiting moments. ACM Transactions on Computer-Human Interaction (TOCHI), 24(1), 1–41.
S17	Kadhem, H. (2017, October). Using mobile-based micro-learning to enhance students; retention of IT concepts and skills. In 2017 2nd International Conference on Knowledge Engineering and Applications (ICKEA) (pp. 128–132). IEEE.
S18	Peng, D. (2017, July). On Platform Construction of English Vocabulary Learning in Higher Vocational Colleges Based on Mobile Micro Learning. In 2017 9th International Economics, Management and Education Technology Conference (IEMETC 2017). Atlantis Press.
S19	Wang, R., Chen, L., Solheim, I., Schulz, T., & Ayesh, A. (2017, March). Conceptual motivation modeling for students with dyslexia for enhanced assistive learning. Proceedings of the 2017 ACM Workshop on Intelligent Interfaces for Ubiquitous and Smart Learning (pp. 11–18).
S20	Göschlberger, B., & Bruck, P. A. (2017, December). Gamification in mobile and workplace integrated microlearning. Proceedings of the 19th International Conference on Information Integration and Web-based Applications & Services (pp. 545–552).
S21	Butgereit, L. (2016, May). Gamifying mobile micro-learning for continuing education in a corporate IT environment. In 2016 IST-Africa Week Conference (pp. 1–7). IEEE.
S22	Rensing, C. (2016, July). A context aware learning application for communities of service technicians. In 2016 IEEE 16th International Conference on Advanced Learning Technologies (ICALT) (pp. 77–81). IEEE.
S23	Meng, J., & Li, Z. (2016, December). Feasibility of Applying Mobile Micro-learning to College English Learning. In 2016 International Seminar on Education Innovation and Economic Management (SEIEM 2016). Atlantis Press.
S24	Huo, C., & Shen, B. (2015). Teaching reform of English listening and speaking in China based on mobile micro-learning. Creative Education, 6(20), 2221–2226.
S25	Simons, L. P., Foerster, F., Bruck, P. A., Motiwalla, L., & Jonker, C. M. (2015). Microlearning mApp raises health competence: hybrid service design. Health and technology, 5(1), 35–43.
S26	Wen, C., & Zhang, J. (2015). Design of a microlecture mobile learning system based on smartphone and web platforms. IEEE Transactions on Education, 58(3), 203–207.

Note. S-ID is the abbreviation of the study's ID.

Appendix 2

Distributions of the publication sources and impacts of the 26 articles

Journals (*n*=15)	f	IF	SJR	Year	S-ID	GS citations
Topic of Medical Science	4					
Vaccine		3.14	1.68	2019	S9	15
The Cureus Journal of Medical Science		1.90	0.14	2019	S6	15
Health and technology		1.12	0.25	2015	S25	37
On-Line Journal of Nursing Informatics		0.41	0.18	2018	S15	2
Topic of Human-Computer Interaction	1					
ACM Transactions on Computer-Human Interaction		3.14	0.83	2017	S16	4
Topic of Education	8					
Contemporary Educational Psychology		2.86	2.15	2019	S5	6
IEEE Transactions on Education		2.27	0.88	2015	S26	65
Journal of Computer Assisted Learning		2.12	1.54	2018	S14	54
Journal of Educational Computing Research		1.95	0.88	2019	S7	3
Technology, Knowledge and Learning		1.67	0.57	2020	S3	11
Creative Education		1.01	-	2015	S24	6
International Journal of Emerging Technologies in Learning (iJET)		1.00	0.33	2020	S2	0
International Journal of Learning and Development		0.67	0.21	2018	S13	2
Topic of Information, Communication, & Technologies	2					
Information		1.98	0.35	2020	S1	2
PACM on Interactive, Mobile, Wearable and Ubiquitous Technologies		-	-	2019	S8	2

Conference Proceedings (*n*=11)	f	IF	SJR	Year	S-ID	GS citations
Topic of Engineering	4					
The 2020 CHI Conference on Human Factors in Computing Systems		-	0.67	2020	S4	0
The 2018 IEEE 11th International Conference on Cloud Computing		-	0.37	2018	S12	1
The 2017 IEEE 2nd International Conference on Knowledge Engineering and Applications		-	0.15	2017	S17	4
The 2016 IEEE IST-Africa Week Conference		-	-	2016	S21	6
Topic of Learning Technologies	4					
The 2016 IEEE 16th International Conference on Advanced Learning Technologies		-	0.23	2016	S22	4
The 2016 International Seminar on Education Innovation and Economic Management		-	-	2016	S23	4
The 2017 9th International Economics, Management and Education Technology Conference		-	-	2017	S18	1
The 2017 ACM Workshop on Intelligent Interfaces for Ubiquitous and Smart Learning		-	-	2017	S19	7
Topic of Information, Communication, & Technologies	2					
The 19th International Conference on Information Integration and Web-based Applications & Services		-	-	2017	S20	19
The 2018 IEEE International Conference on Information and Communications Technology		-	-	2018	S10	3
Topic of Business	1					
The 2018 IEEE 5th International Conference on Business and Industrial Research		-	-	2018	S11	4

Note. IF = impact factor. SJR = SCImago Journal Ranking (SJR). S-IDs = the ID of the selected studies. GS citations = Google Scholar citations.

Table 1. The final qualified articles (N=26) and their ID numbers.

S-ID	Author(s) (Year)	S-ID	Author(s) (Year)
S1	De Troyer et al. (2020)	S14	Nikou & Economides (2018)
S2	Chai-Arayalert & Puttinaovarat (2020)	S15	ONeill et al. (2018)
S3	Jahnke et al. (2020)	S16	Cai, Ren, & Miller (2017)
S4	Hudson et al. (2020)	S17	Kadhem (2017)
S5	Epp & Phirangee (2019)	S18	Peng (2017)
S6	Shail (2019)	S19	Wang et al. (2017)
S7	Pham & Chen (2019)	S20	Göschlberger & Bruck (2017)
S8	Hautasaari et al. (2019)	S21	Butgereit (2016)
S9	Dale et al. (2019)	S22	Rensing (2016)
S10	Norsanto & Rosmansyah (2018)	S23	Meng & Li (2016)
S11	Ohkawa et al. (2018)	S24	Huo & Shen (2015)
S12	Sun et al. (2018)	S25	Simons et al. (2015)
S13	Hanshaw & Hanson (2018)	S26	Wen & Zhang (2015)

Note. S-ID is the abbreviation of the study's ID. The full bibliography is listed in the Appendix 1.

Table 2. Data extraction criteria of the 26 articles.

Research Questions	Data Extraction Criteria
RQ1: What are the general characteristics, including research purposes and the source and year of publications, reported in MML studies?	**0.** Basic information of the article (e.g., the year of publication, impact factor, country of publication) **1.** Research purposes
RQ2: What are the research settings, including learning domains, learning platforms, and supported learning technologies, applied in MML studies?	**2.** Types of learning domain and contexts (formal, informal, nonformal) **3.** Types of learning platforms (self-developed, existing app) **4.** Study approaches (qualitative, quantitative, mixed), measures (survey, interview, etc.), and participants (k-12 students, domain-specific professionals, etc.)
RQ3: What are the research outcomes of learner experiences, advantages, and challenges of MML as identified in MML studies?	**5.** Study outcomes of learner experiences (positive, negative, etc.) **6.** Advantages and challenges of MML studies

Table 3. The process of data extraction, analysis, and synthesis of the 26 articles.

Phase 1	*Uploading* all the 26 selected articles in PDF format into the Atlas.ti 8 for the readiness of data coding.
Phase 2	*Reading* the text of the articles to get familiar with the entire study structure and make sense of where and what components of the study were meaningful to retrieve.
Phase 3	*Coding* and *extracting* the relevant attributes from all articles and clustering these attributes into the seven identified criteria (deductive strategy, see Table 2).

Phase 4	*Synthesizing* similar attributes into the same group (or *inductive category*) and *creating* a common name (theme) for each group (inductive strategy). Each identified criteria consisted of several categories that were shown in the Results section.
Phase 5	*Frequency calculating* of articles occurred in each category (a quantitative content analysis).
Phase 6	*Cross analyzing* with frequency values of the attributes among categories and presenting analysis results with charts and tables.

Table 4. Distributions of the research purposes of the 26 studies.

Inductive Categories	f	%	Year (S-ID)	Examples of Categories Code
To enhance professional skills and knowledge in the workplace	7	26.92	2018 (S10, S12, S13, S15); 2017 (S20); 2016 (S21, S22)	To keep all employees abreast of the latest programming techniques and trends (S21). To support modular and situated learning in a group of service technicians (S22). To enhance civil servants' knowledge and user engagement (S10).
To improve language capability	7	26.92	2020 (S4). 2019 (S5, S8). 2018 (S11). 2017 (S18). 2016 (S23). 2015 (S24).	To prove the feasibility of applying mobile microlearning to college English learning(S23). To enhance speech and language therapist training (S4). To allow users to discover new vocabulary items while walking past buildings, shops, and other locations (S8).
To enhance learners' engagement, learning motivation, and knowledge and skill retention	7	26.92	2019 (S6, S7); 2018 (S14); 2017 (S16,S17, S19); 2015 (S26).	To enhance the learning experience (S19). To help students retain more knowledge and skills, and to support classroom learning (S17) To improve high school students' motivation and learning performance (S14).
To promote lifelong learning	2	7.69	2020 (S1, S2)	To transform learning into a pleasant activity and a seamless part of daily life (S1). To make learners pay more attention to their outside-classroom learning, lifelong learning (S2).
To promote health care knowledge	2	7.69	2019 (S9); 2015 (S25)	To promote long term health (S25). To increase users' visiting of a sponsored pharmacy mobile app to discuss and receive the influenza vaccine (S9).
To synthesize MML design principles	1	3.85	2020 (S3)	To unpack MML platforms and their inherent design principles (S3).

Notes. f = the frequency calculation of articles occurring in each category. % = the distributions of percentages of articles occurring in each category. Year = the year of publication of the article.

Table 5. Distributions of learning domains and learning contexts in 26 studies.

Learning Domains	f (%)	Learning Contexts			
		Formal	*Informal*	*Nonformal*	*Blended*
		8 (30.77)	12 (46.15)	4 (15.38)	2 (7.69)

	f (%)			
Language learning	8 (30.77)	$2019\,(S5)_{young}^{self-dev.}$ $2018\,(S11)_{adult}^{self-dev.}$ $2017\,(S18)_{adult}^{exi.app}$ $2016\,(S23)_{adult}^{NA}$ $2015\,(S24)_{adult}^{NA}$	$2019(S7,S8)_{mix.age}^{self-dev.}$ $2017(S16)_{adult}^{self-dev.}$	
Workplace training	5 (19.23)		$2018\,(S10)_{adult}^{self-dev.game}$ $2018\,(S13)_{adult}^{NA}$ $2017\,(S20)_{adult}^{exi.app.game}$ $2016\,(S21)_{adult}^{self-dev.game}$ $2016\,(S21\,S22)_{adult}^{self-dev.}$	
Engineering education	3 (11.54)	$2016\,(S17)_{adult}^{exi.app}$ $2015\,(S26)_{adult}^{self-dev.}$		$2018(S12)_{adult}^{self-dev.}$
Science	2 (7.69)	$2018\,(S14)_{young}^{self-dev.}$		$2017(S19)_{young}^{self-dev.}$
Healthcare	2 (7.69)		$2019\,(S9)_{mix.age}^{self-dev.}$	$2015(S25)_{adult}^{self-dev.}$
Liberal Arts	2 (7.69)		$2020(S1)_{mix.age}^{self-dev.}$	$2020\,(S4)_{mix.age}^{self-dev.}$
Ecology	1 (3.85)		$2020\,(S2)_{mix.age}^{self-dev.}$	
Nursing	1 (3.85)		$2018\,(S15)_{adult}^{exi.app.game}$	
No specific	2 (7.69)			$2020(S3)_{adult}^{exi.app}$ $2019(S6)_{adult}^{self-dev.}$

Table 6. Distributions of study approaches and measurement instruments.

Study approach & Measurements	f	%	Year (S-ID)
Quantitative	17	65.38	
Survey	8	30.77	2019 (S9) 2017 (S18) 2016 (S21, S22, S23) 2015 (S24, S25, S26)
Observation	4	15.38	2019(S7) 2018(S11, S12) 2017(S20)
Pretest and posttest	2	7.69	2018 (S10, S15)
Achievement test	1	3.85	2017 (S17)
Survey + achievement test	1	3.85	2019 (S8)
Survey + pre-posttests	1	3.85	2018 (S14)
Mixed methods	5	19.23	
Interview + survey	2	7.69	2020 (S2) 2018 (S13)
Interview + literature review	1	3.85	2020 (S3)
Interview + achievement test + survey	1	3.85	2017 (S16)
Observation + achievement test	1	3.85	2018 (S5)
Qualitative	4	15.38	
Interview	3	11.54	2020 (S1, S4) 2017 (S19)
Literature review	1	3.85	2019 (S6)

Table 7. Distributions of study outcomes of learner experiences.

Study outcomes & Focused impacts	f	%	Year (S-ID)
Positive impacts	20	76.92	
Learning effectiveness	4	15.38	2019 (S8), 2017 (S17), 2015 (S24, S25)
Fulfillment of learner needs	4	15.38	2020 (S4), 2017 (S19), 2016 (S22, S23)
Effectiveness and engagement	3	11.54	2018 (S10, S15), 2017 (S16)

	f	%	Year (S-ID)
Learning engagement	2	7.69	2019 (S6), 2016 (S21)
Effectiveness and interest	2	7.69	2019 (S7), 2015 (S26)
Effectiveness and motivation	2	7.69	2020 (S1), 2018 (S14)
Learner interests	1	3.85	2020 (S2)
Engagement and interest	1	3.85	2019 (S9)
Effectiveness & learner needs	1	3.85	2018 (S13)
Not all types of learners had positive impacts by MML	4	15.38	2019 (S5), 2018 (S11, S12), 2017 (S20)
Reported design principles of MML without specific learning outcomes	2	7.69	2020 (S3), 2017 (S18)

Table 8. Distribution of advantages and deficiencies of MML studies.

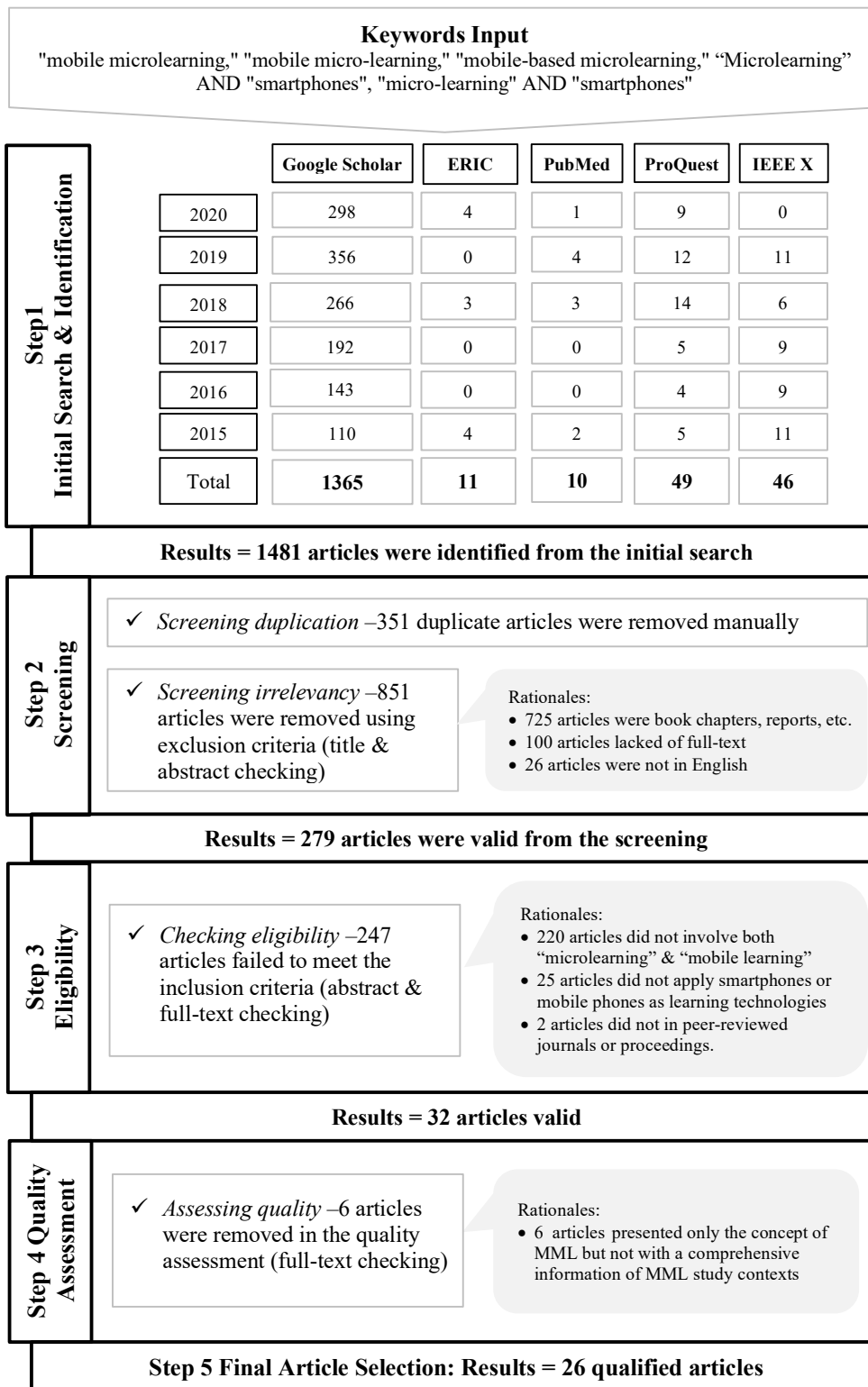| Advantages of MML	f	%	Year (S-ID)
Learn in diverse contexts (formal, informal, nonformal)	6	23.08	2020 (S1), 2019 (S7), 2018 (S11), 2017 (S18), 2015 (S24, S25)
Learn just in time (action oriented), especially in the workplace	4	15.38	2020 (S4), 2018 (S13, S15), 2016 (S22)
Learn at a self-determined pace	4	15.38	2020 (S2, S3), 2019 (S6), 2015 (S26)
Learn anytime, anywhere	3	11.54	2019 (S8), 2017 (S16), 2016 (S23)
Behavior of learners changes	3	11.54	2019 (S9), 2017 (S20), 2016 (S21)
Perceived control, individualized, privacy, and enjoyment by learners	3	11.54	2018 (S10, S12), 2017 (S19)
Facilitate information processing and reduce cognitive load (mental fatigue)	3	11.54	2019 (S5), 2018 (S14), 2017 (S17)
Deficiencies of MML			
No statement of MML deficiencies	13	50.00	2020 (S1), 2019 (S6, S7, S8, S9), 2018 (S10, S13, S14), 2017 (S16, S18, S19), 2016 (S21), 2015 (S25)
Lack of user experience and usability test	5	19.50	2020 (S2), 2018 (S11), 2017 (S17), 2016 (S22, S23)
Lack of designing for higher order thinking skills (create, evaluate, analyze)	2	7.69	2020 (S3), 2018 (S15)
Lack of offline versions (easy accessibility for learning contents)	1	3.85	2020 (S4)
Lack of deep interactions during the learning process	1	3.85	2019 (S5)
Lack of considering teaching purposes, students' characteristics, abilities, and knowledge structure	1	3.85	2015 (S24)
Lack of metadata to provide reliable recommendations for learners	1	3.85	2018 (S12)
Lack of intrinsic motivation factors	1	3.85	2017 (S20)
Learners were easily distracted by the learning technologies	1	3.85	2015 (S26)

Keywords Input
"mobile microlearning," "mobile micro-learning," "mobile-based microlearning," "Microlearning" AND "smartphones", "micro-learning" AND "smartphones"

Step1 Initial Search & Identification

	Google Scholar	ERIC	PubMed	ProQuest	IEEE X
2020	298	4	1	9	0
2019	356	0	4	12	11
2018	266	3	3	14	6
2017	192	0	0	5	9
2016	143	0	0	4	9
2015	110	4	2	5	11
Total	**1365**	**11**	**10**	**49**	**46**

Results = 1481 articles were identified from the initial search

Step 2 Screening

✓ *Screening duplication* –351 duplicate articles were removed manually

✓ *Screening irrelevancy* –851 articles were removed using exclusion criteria (title & abstract checking)

Rationales:
- 725 articles were book chapters, reports, etc.
- 100 articles lacked of full-text
- 26 articles were not in English

Results = 279 articles were valid from the screening

Step 3 Eligibility

✓ *Checking eligibility* –247 articles failed to meet the inclusion criteria (abstract & full-text checking)

Rationales:
- 220 articles did not involve both "microlearning" & "mobile learning"
- 25 articles did not apply smartphones or mobile phones as learning technologies
- 2 articles did not in peer-reviewed journals or proceedings.

Results = 32 articles valid

Step 4 Quality Assessment

✓ *Assessing quality* –6 articles were removed in the quality assessment (full-text checking)

Rationales:
- 6 articles presented only the concept of MML but not with a comprehensive information of MML study contexts

Step 5 Final Article Selection: Results = 26 qualified articles

Figure 1. Article search and selection procedure.

	2015	2016	2017	2018	2019	2020
Journal	S24, S25, S26	No article	S16	S10, S11, S12	S5, S6, S7, S8, S9	S1, S2, S3
Conference	No article	S21, S22, S23	S17, S18, S19, S20	S13, S14, S15	No article	S4
Country of the Study	China (S24, S26) Netherlands (S25)	Africa (S21) Germany (S22) China (S23)	USA (S16) Mid East (S17) China (S18) Norway (S19) Austria (S20)	USA (S13, S15) Indonesia (S10) Japan (S11) Australia (S12) Europe (S14)	Canada (S5, S6, S9) Global (S7) Japan (S8)	Belgium (S1) Thailand (S2) USA (S3) Africa (S4)

Figure 2. Number of articles by year, source of publication (journal or conference), and country of study.

A list of Figure captions:

Figure 1. Article search and selection procedure.

Figure 2. Number of articles by year, source of publication (journal or conference), and country of study.

Appendix 2–Article 2: Digital Skills of Mobile Journalists: Exploring Learning Needs and Learner Experiences of Just-in-Time Learning with Smartphones

Article 2: accepted in the *Journal of Journalism & Mass Communication Educator (JMCE).*

Digital Skills of Mobile Journalists: Exploring Learning Needs and Learner Experiences of Just-in-Time Learning With Smartphones

Yen-Mei Lee[1] (iD)

Abstract

Through a semi-structured survey of mobile journalists ($N = 433$), the study investigated mobile journalists' learning needs and learner experiences related to their digital skills development with smartphones. Results indicate that not only novice journalism students but also experienced educators, professionals, or mass communication and media workers had a high level of demands on developing specific digital skills, especially skills with smartphones, such as writing better headlines and stories for mobile audiences, shooting and editing 360° videos, and programming skills such as HTML. Recommendations are made for future research that mobile journalists indicated mobile microlearning is a promising approach to support their just-in-time learning.

Keywords

mobile journalists, digital skills, learning needs, mobile microlearning, just-in-time learning

Introduction

Mobile journalism (MoJo) has rapidly moved to embrace mobile technologies as tools of gathering and disseminating digital news since the late 2000s (Cameron, 2009; Martyn, 2009; Marymont, 2006). In particular, smartphones have become an important resource in journalists' daily work routines in the 21st century (Kitsa, 2019;

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Salzmann et al., 2020). The nexus of smartphones allows journalists to process information on the go within minutes and quickly edit and report news anywhere from the field at any time (Cervi et al., 2020; Westlund & Quinn, 2018). By consequence, this change creates a need for mobile journalism education (Bui & Moran, 2020).

Mobile journalists (MoJos) are solo reporters who use their smartphones as a comprehensive production unit for newsgathering, editing, and dissemination (Salzmann et al., 2020). Because the mobile media have changed from a 24-hr news cycle to a minute-by-minute update format (Costello & Oliver, 2018), journalists must report news as soon as they gather it, digesting it and breaking it down into smaller pieces of mobile-friendly contents (Wenger et al., 2014). Therefore, digital skills with smartphones are requested by news companies and media industries when they hire employees to write multiplatform-appropriate headlines for mobile audiences, push breaking news on social media, and create original stories according to recorded documents (Wenger et al., 2018). This new phenomenon leads to the following research questions: What are the specific digital skills with smartphones that MoJos urgently *need*? Which new digital skills do they *want* to develop (in addition to the digital skills that they already have)? What types of learning formats do they perceive as useful for supporting their on-demand learning?

Mobile microlearning (MML) is a promising way to support MoJos' on-demand learning because it can customize chunk-size instructions within 5 min and be delivered in mobile applications (Costello & Oliver, 2018; Emerson & Berge, 2018; Jahnke et al., 2020). However, evidence-based investigations of whether MoJos themselves want and need to engage in this type of learning are lacking. Therefore, guided by Knowles's theory of adult learning, the study aims to investigate the kinds of digital skills that MoJos learn on demand and whether MML is perceived as a potential approach to support MoJos' just-in-time learning. The ultimate purpose of this study is to contribute to the body of academic journalism research and provide insights into and explicit learning approaches for the training of MoJos.

Aligned with the study purpose, three research questions (RQs) are proposed as follows:

RQ1: What types of digital skills with smartphones do MoJos need?
RQ2: What ways of learning do MoJos perceive as useful to support the development of their digital skills?
RQ3: How do MoJos perceive MML as a potential learning approach to support their just-in-time learning?

Literature Review

Digital Mobile Skills Desired in the 21st-Century Mobile Journalism

The need for digital skills with smartphones is changing rapidly due to the continuous development of mobile technologies (Kitsa, 2019; Wenger et al., 2014). According to Wenger et al. (2018), journalism educators are aware of this phenomenon.

To understand what kinds of digital skills are requested and needed in 21st-century journalism education, Wenger et al. investigated more than 18,000 journalistic job positions from the top 10 news companies in the United States from 2010 to 2015. Wenger et al. (2018) indicate that digital skills on mobile devices are essential criteria for several job positions: web-related positions listed these skills as a 100% critical requirement; more than two thirds (69.6%) of news director jobs required these criteria, and other positions, such as print and broadcast producers and anchors, also asked for mobile capabilities.

Aligned with Wenger et al.'s (2018) study, a comprehensive digital skillset was proposed as a learning guide for mobile journalism education, including shooting and editing videos and audios with mobile devices, writing better headlines and stories for mobile audiences; using social media skills (e.g., Facebook Live stream, Snapchat, and Instagram) for storytelling or personal branding; and using multiplatform skills (especially mobile apps) and audience analytics to drive traffic, using data journalism to develop enterprise stories, creating simple graphics (e.g., maps, charts), and telling stories using podcasts. These identified skills guide the present study in identifying what specific digital skills are important to MoJos regarding their continuing professional development.

Educators have already started to integrate digital mobile skills training into journalistic learning contexts to prepare MoJos with skills ready for the job market (Cervi et al., 2020). For instance, Kraft and Seely (2015) examined the improvement of journalism students' news reporting skills, using iPads as tools, and obtained positive results. Cervi et al. (2020) examined a massive open online course (MOOC) delivered to MoJos' smartphones for their digital skills training and explored the course structure and functioning. However, these studies focused on technologies and materials, whereas Knowles's adult learning theory asserts that to design a high-quality curriculum for specific learners, one must first listen to what the learners need and want to learn. Learners' needs can be a foundation that supports educators' decisions on the design of learning contents, formats, media usages, and learning environment settings (Thomas et al., 2016). Hence, the study targeted on learner needs and experiences in journalism education.

MoJos' On-Demand Learning: Just-in-Time and Just Enough With MML

MoJos may encounter problems that they have not learned in school or training (Maniou et al., 2020). For example, they may need specific techniques or IT skills to record interviews from the field with their smartphones, or they may need immediate suggestions to create news headlines on the go. When encountering such problems, MoJos have the desire to learn "anytime, anywhere, anyhow" (Brandenburg & Ellinger, 2003, p. 308), and they want to acquire skills that are useful, immediately impact their work, and solve problems (Costello & Oliver, 2018; Knowles, 1980). To learn on-demand and just when needed, smartphones can be used to deliver lessons for MoJos to solve problems (Costello & Oliver, 2018). This learning format is called on-demand or just-in-time learning.

It is essential to rethink how effective learning should occur to support MoJos' goal-oriented and self-directed learning—they want to learn just in time and just enough for performing tasks from the field (Maniou et al., 2020). However, as argued by Costello and Oliver (2018), just-in-time learning raises questions surrounding the complexity of content and the length of the course for busy journalists' practice.

MML may be a potential solution to support MoJos with just-in-time learning because it aims to deliver bite-size units, which can be effectively absorbed by journalists (Costello & Oliver, 2018). Generally, each MML lesson is between 30 s and 5 min and presents only one concept (factual knowledge related to job skills) at a time (Jahnke et al., 2020). MoJos from the field can pause and continue the microlesson on their smartphones, continually check their learning performance, and adjust their learning progress when they need to (Shail, 2019). In this case, MML seems to be an accessible learning approach that allows MoJos to learn whenever they need it; however, there is a lack of evidence regarding whether MoJos perceive this type of learning is useful. This study aims to fill this knowledge gap.

Theoretical Framework

Learner needs are defined as the learner's expectations, demands, and feelings of the necessity to acquire specific knowledge and skills (Abuzid, 2017; Khikmatova, 2020; Ooi et al., 2019). Learner needs are addressed as the discrepancy between the present level of competency and the required level of competency, which can refer to the learner's expectations or organizational and social requirements (Knowles, 1980). In journalism education, MoJos' learning needs are the discrepancy between the present level of digital skills and the level of digital skills required by 21st-century news companies or media industries (Wenger et al., 2018). However, the specific digital skills that are needed by MoJos to enhance their present capacities and the learning approach that can fulfill MoJos' demands of just-in-time learning are unclear.

To analyze learner needs, two components of learner analysis are suggested by Thomas et al. (2016): learners' general characteristics (e.g., gender, work experience, and position status) and learning experiences (e.g., preferred learning formats or successful learning methods). The framework for studying MoJos' learning needs (the discrepancy) is described in Figure 1.

Method

A semi-structured survey method with a mixed data analysis approach (Benesty et al., 2009; Mayring, 2004) was applied in this study.

Data Collection and Measures

The data were collected in the summer of 2017 through an online questionnaire that consisted of 18 items, including 12 closed questions and 6 open-ended questions, asking for MoJos' general characteristics (e.g., gender, position status, and years of work
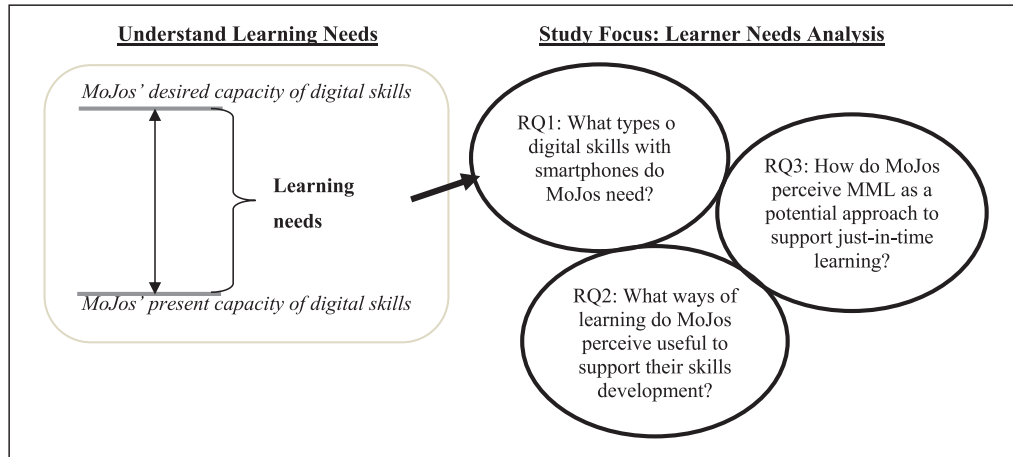
Figure 1. Theoretical framework of MoJos' learning needs (Adopted from Knowles' adult learning theory—learner needs assessment).

experience in journalism), their needs for developing digital skills with smartphones, and their successful experiences of learning digital skills. Ten digital skills were identified as the investigation items, according to those found in Wenger et al. (2018) and Wenger et al. (2014). The questionnaire is in the Appendix.

Participants and Sampling

The study selected the participants from the population of interest, including student journalists and professional journalists. In total, 835 potential contacts were provided by the School of Journalism. The survey was distributed via email using the contact list, social media, and online flyers. During the survey distribution process, two to three follow-up emails were sent to increase the response rate. Two $50 gift cards were offered as a compensation to encourage participation. A screening question was provided as the first question item in the survey to automatically exclude irrelevant participants and recruit only the target population: journalism students, educators, journalism professionals, and mass communication and media (MCM) workers. After data collection was completed, the qualified responses were screened to ensure the final sample was representative. Missing responses or incomplete survey answers were excluded before the data analysis. The final qualified survey responses are presented in the results section.

Data Analysis

Quantitative data (closed questions with five-point Likert-type scales, from 1—"strongly disagree" to 5—"strongly agree") were analyzed using three statistical methods: Pearson's correlation coefficient, the one-way analysis of variance (ANOVA), and the multiple regression analysis by SPSS statistics software (Benesty et al., 2009;

Table 1. Participants' Demographic Information in the Four Groups.

Participants	N	Gender n (%)		
		Male	Female	No pref.
Total (all groups)	433	170 (39)	195 (45)	68 (16)
Journalism students	27	8 (30)	16 (59)	3 (11)
Journalism educators	64	24 (38)	30 (47)	10 (15)
Journalism professionals	293	118 (40)	128 (44)	47 (16)
MCM workers	49	20 (41)	21 (43)	8 (16)

Note. "No pref." means that the participants do not prefer to answer. MCM = mass communication and media.

Park, 2009). Qualitative data (open-ended questions) were analyzed using the content analysis method and are presented by percentage (%) and the frequency of count (*f*) (Mayring, 2004).

Results

The study received a total of 690 responses and 433 complete responses; the response rate was 62.75%.

Participants' Demographics

Of the 433 participants who gave complete responses, 39% were males, 45% were females, and 16% expressed no gender preference. Table 1 shows the four groups of journalists, including 27 journalism students, 64 journalism educators, 293 journalism professionals, and 49 mass communication and media (MCM) workers whose work is related to journalism. Across all participants, the number of years of work experience ranged from less than 1 year to more than 20 years.

Across all groups, there was no significant gender difference between male, female, and people who prefer not to indicate their gender, $F(2, 432) = 2.32$, $p = .09$. Only the professional group showed a significant gender difference, $F(2, 363) = 4.03$, $p = .02$, that female professionals have higher needs than male professionals according to the Tukey's honest significant difference post hoc test ($p = .039$). In addition, there was no significant gender difference when comparing the years of work experience among the five categories (less than 1 year, 1–4 years, 5–9 years, 10–19 years, and 20 and more years of work experience), $F(4, 432) = 2.03$, $p = .09$.

Types of Digital Skills With Smartphones MoJos Need (RQ1)

A Likert-type scale was used to analyze the level of need with six sub-questions, giving a total of 6 to 30 points. The four groups scored as follows: journalism students
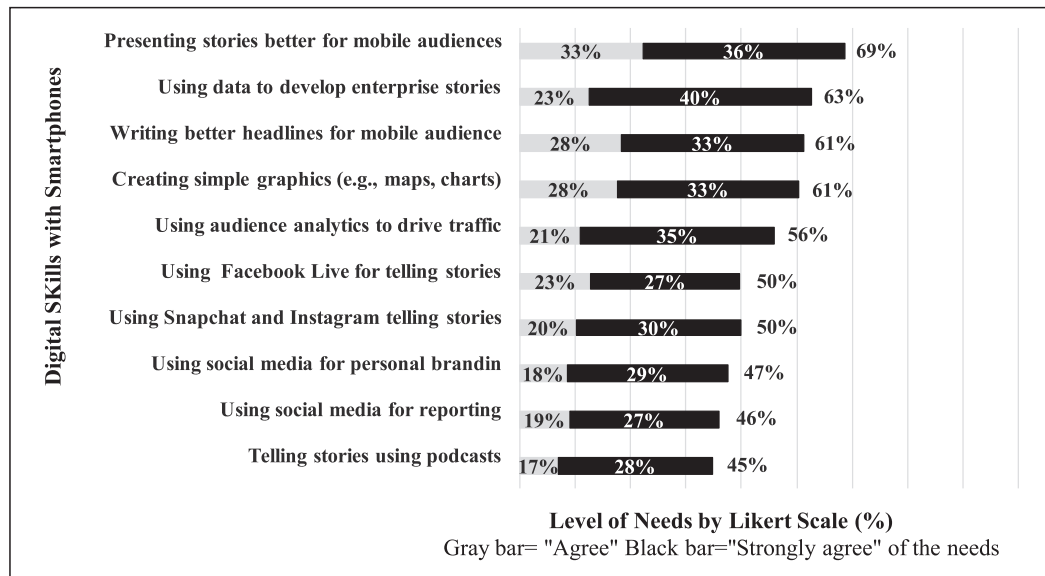
Figure 2. Participants' needs of the 10 digital skills.

($M = 18.62$, $SD = 5.03$), professional journalists ($M = 18.92$, $SD = 5.67$), the MCM workers ($M = 20.79$, $SD = 5.51$), and the educator group ($M = 20.89$, $SD = 4.96$). The educator group showed the highest mean score, but there was no statistically significant difference among the four groups according to the one-way ANOVA, $F(3, 432) = 2.50$, $p = .08 > .05$. Therefore, all participants had a high level of need to develop digital skills in using smartphones for news reporting.

In addition, 10 digital skills identified from the literature (Wenger et al., 2014, 2018) were used to investigate participants' need to develop specific skills. Participants were asked to rank each skill on a Likert-type scale from 1 (*strongly disagree*) to 5 (*strongly agree*) to present their needs. Figure 2 shows the percentage of participants who agreed or strongly agreed that they needed each skill. "Presenting stories better for mobile audiences" was the most needed skill, indicated by 69% of participants (36% strongly agree and 32% agree). Detailed information is shown in Figure 2.

Using an open-ended question, participants were also asked about additional digital skills that they wanted to develop. Participants frequently mentioned "social media skills" (frequency of count, $f = 53$), "news headlines, storytelling, breaking news writing skills" ($f = 29$); "data visualization and search engine optimization skills" ($f = 21$); "basic programming and coding skills such as HTML, CSS, and JavaScript" ($f = 15$); and "shooting and editing 360-degree, remote, virtual reality (VR) and augmented reality (AR) videos" ($f = 8$).

To deeply examine the kinds of digital skills that each subgroup needed, a multiple regression analysis was conducted. The 10 digital skills (questionnaire items #5 and #6) were predictors (independent variables) of participants' level of learning needs (dependent variable, questionnaire item #4). Results are shown in Table 2. The 10

Table 2. Predicting the Needs of Developing Digital Skills With Smartphones Among the Four Groups (Journalism Students, Educators, Professionals, MCM Workers) Using the Regression Analysis.

Predictors: digital skills with smartphone	Regression analysis by groups coefficient with β-value (std. error)				
	All groups (n = 433)	Students (n = 27)	Educators (n = 64)	Professionals (n = 293)	MCM workers (n = 49)
Using social media for reporting	.92 (.19)	1.84 (.73)*	.81 (.40)*	.93 (.26)*	.88 (.58)
Using social media for personal branding	.20 (.20)	.75 (.77)	.19 (.46)	.05 (.26)	.55 (.65)
Using Facebook Live stream for story telling	.57 (.20)*	1.25 (.80)	.57 (.47)	.51 (.26)*	1.75 (.71)*
Using Snapchat and Instagram for story telling	.33 (.19)	.03 (.80)	1.12 (.48)*	.15 (.24)	.04 (.67)
Using audience analytics to drive traffic and inform coverage	.39 (.19)*	-.07 (.77)	.82 (.43)	.32 (.26)	.69 (.68)
Writing better headlines for mobile audiences	.51 (.23)*	1.72 (1.38)	.78 (.47)	.46 (.30)	1.31 (.73)
Presenting stories better for mobile audiences	.13 (.25)	.25 (1.20)	.16 (.58)	.20 (.33)	.67 (.81)
Using data journalism to develop enterprise stories	-.14 (.20)	-.29 (.81)	-.38 (.44)	-.05 (.28)	.12 (.52)
Creating simple graphics, such as maps and charts	.51 (.21)*	-1.08 (.89)	-.49 (.57)	.60 (.27)*	1.32 (.72)
Telling stories using podcasts	.92 (.17)	1.22 (.68)	.46 (.44)	1.04 (.22)	.89 (.62)
	F = 25.43*	F = 3.98*	F = 6.13*	F = 15.54*	F = 5.14*
	Inter. = 4.47	Inter. = 6.14	Inter. = 6.17	Inter. = 4.53	Inter. = 9.39
	R^2 = .36	R^2 = .31	R^2 = .45	R^2 = .33	R^2 = .26

Note. "*" = the *p* value of the result is < .05, which means the result is statistically significant; Inter. = the intercept; R^2 (standardized R^2) = the degree of explaining the variance in the dependent variable; MCM = mass communication and media.

digital skills were significantly predictive of participants' needs for developing digital skills with smartphones, according to the ANOVA statistics in all groups, $F(3, 432) = 25.43, p < .05, R^2 = .36$. This means that all the participants needed to develop these 10 digital skills.

The predictors with the highest Beta value (β) are the most important variables in interpreting the learning needs. Results across all groups indicated that "using Facebook Live stream function for storytelling" was the strongest predictor, with the value β = .57. This was followed by the scores for "writing better headlines for mobile audiences," "creating simple graphics (e.g., maps and charts) on smartphones," and "using audience analytics to drive traffic and inform coverage." Therefore, these four skills were the most important digital skills with smartphones that MoJos need.

Looking into each group, "using social media for reporting" was the strongest predictor of learning needs in the student group (β = 1.84) and the professional group (β = .93). "Using Snapchat and Instagram for storytelling" was the strongest predictor (β = 1.12) in the education group, and "using Facebook Live stream function for storytelling" was the strongest predictor (β = 1.75) in the MCM group. Accordingly, different groups needed different skills when using smartphone applications to report news.

The Ways of Learning MoJos Perceived Useful in Developing Digital Skills (RQ2)

Across all groups, participants' needs significantly correlated with their most successful way of learning digital skills ($r = .139, p = .002$). When looking deeper into each group, the professional group ($r = .166, p = .003$) and the MCM group ($r = 0.259, p = .039$) had significant correlations between their need to develop digital skills with smartphones and their most successful ways of learning digital skills. In contrast, there was no significant correlation in the student group ($r = .215, p = .163$) or the educator group ($r = .003, p = .488$).

Results of the content analysis showed that "in-person workshops and conferences" were perceived as the most successful way of learning digital skills (before the COVID-19 pandemic) by 45% of educators ($f = 29$), 30% of journalism professionals ($f = 89$), and 22% of MCM workers ($f = 6$). This was followed by "teaching themselves by watching video or reading" and "asynchronous online learning." In contrast, 22% of students ($f = 6$) indicated that their most successful way of learning digital skills was "teaching themselves by watching video or reading," followed by "in-person workshops and conferences" and "college classes." "Live online training at a set time" (e.g., webinars) was least selected by all the four groups.

Open-ended questions were asked about why participants felt that the ways they proposed were successful in supporting their learning.

In-person workshops or conferences. MoJos stated that this facilitated asking questions and receiving immediate feedback. They also appreciated the opportunity to interact and learn together with others, have hands-on exercises, and leave daily work to reduce the distractions from learning. Participants' (P) comments are shown below:

> *"Real-time interaction with other learners, in person, afforded me the benefits of hearing others' points of view, questions, etc."* (P23-MCM worker)
> *"In-person causes me to stop and think intensively about that one thing. It's hard to integrate learning (steep learning curve) with regular work."* (P103-educator)

Teaching themselves and asynchronous online training. Flexibility is key. MoJos stated that they could select what they needed based on their own situation, learn on their own pace, and refer back and retrieve learning content anytime as needed. Participants commented the following:

> *"I can learn at my own pace, in the style that works best for me (re-watching/re-reading multiple times, for example) for whatever specifically needs to be done at the time."* (P47-professional)
> *"Because it was on-the-go, during my reporting process or while editing audio or video. It had a sense of urgency and yet excitement at the same time like journalism."* (P3-educator)

Informally learning from a colleague. MoJos indicated that they appreciated the flexibility and efficiency of this mode of learning. They commented that they could ask questions and receive immediate feedback from colleagues when they had specific needs. Examples of responses include the following:

> *"They (colleagues) could answer questions that were specific to what I did not already know in a brief, time-efficient manner"* (P213-MCM worker).
> *"Allowed me to target very specific skills I needed, ask questions without feeling stupid, did not waste any time on subjects I already know"* (P323-professional).

Live online training at set times. Participants indicated that they could have interactions with instructors and peers in real time without traveling somewhere. They could participate in such training for a short time while they were at work, have questions answered, and obtain instant feedback and correction.

MoJos' Perceptions About MML for Digital Skills Development (RQ3)

Willingness to Spend Time on Digital Skills Learning

Approximately half of the participants (45.73%) were "willing to spend 31 to 60 min per week" on mastering one digital skill; this means the participants would be happy to spend 4 to 8 min per day on learning a digital skill. In addition, one-fifth of participants (17.78%) were "willing to spend 16–30 min per week" on learning, which means that they would be happy to spend 2 to 4 min per day on learning a digital skill. More detailed information is shown in Table 3.

Table 3. Time Participants Are Willing to Spend on Mastering One Digital Skill Per Week.

Time per week (min)	Participants *n* = *344* (%)
31–60 min	198 (45.73)
16–30 min	77 (17.78)
61–120 min	75 (17.32)
121 min or more	32 (7.39)
1–15 min	18 (4.16)
None	7 (1.62)
No answer	26 (6.00)

Note. % = percentage of the total number of participants; *min* = minutes.

Willingness to learn with mobile micro lessons. The results indicated the willingness to try a 15-min microlesson for mastering a digital skill on smartphones. A Pearson's correlation analysis showed a weak (r = .251) but statistically significant positive (p < .000) correlation between the participants' willingness to learn with a mobile-based short lesson and their need to develop digital skills with smartphones. Furthermore, a regression analysis indicated that the participants' level of willingness to learn with a mobile-based short lesson could significantly predict the level of need to develop their digital skills, $F(1, 432)$ = 29.14, β = 2.22, p < .000. This means higher the level of willingness to spend the time in learning, the more needs of learning MoJos perceive.

Discussion

The study aimed to examine MoJos' learning needs and learner experiences toward their digital skills development with smartphones. More than half of the 433 participants "agreed" or "strongly agreed" that they had learning needs, including writing better headlines, optimizing the presentation of stories for mobile audiences, and creating simple graphics (e.g., maps and charts) on smartphones. All groups—novice journalism students, experienced educators, journalism professionals with more than 20 years' work experience, and MCM workers—had a high need to develop digital skills with smartphones.

Different types of MoJos indicated needs to learn different specific digital skills, which was subsequently reflected in the regression analysis. The use of social media for news reporting (e.g., Twitter feeds) was the most urgent learning need for journalism students and professionals; the use of Snapchat and Instagram for storytelling was the most urgent learning need for journalism educators; the use of Facebook Live stream for storytelling was the most urgent learning need for MCM workers. These results align with past research which has indicated that the 21st-century journalism training is going beyond journalism schools, and different types of MoJos learn on-demand to continuously enhance specific digital skills according to their own needs, especially the need for skills with smartphones (Bui & Moran, 2020; Kitsa, 2019; Maniou et al., 2020).

Furthermore, this study identifies additional digital skills that MoJos learn on-demand: shooting and editing 360° videos, creating VR and AR videos, and basic programming and coding skills such as HTML, CSS, and JavaScript. This finding corresponds to Mabrook and Singer's (2019) statement that there is an increasing need to create 360° videos and VR storytelling pieces in mobile journalism because these media enable consumers to engage "inside" the environment to embody virtual characters, explore virtual spaces, and make sense of their own experiences within the news stories (Mabrook and Singer, 2019). VR-based storytelling is technically complex—it must be shot using multiple cameras and digitally stitched together to produce a seamless virtual environment. This requires comprehensive skills such as virtual storytelling, programming, user experience, and interaction design, and motion graphic design. Therefore, further research is needed to provide empirical evidence about which training formats can effectively cultivate such advanced digital skills.

The study also reveals that MoJos' learning needs correlate significantly with their successful ways of learning. MoJos indicated that their most successful learning experiences were through attending in-person workshops and conferences—these learning modes gave them a specific time for learning outside of their daily work, as well as a chance to participate in hands-on exercises and receive immediate feedback. Notably, the MoJos in the study indicated that they found live online learning at a set time (e.g., webinars) less effective than in-person workshop training. However, the study was conducted before the COVID-19 pandemic. Due to the sudden outbreak of the pandemic, journalism education is facing challenges, and learning methods have been dramatically changed (Crawford et al., 2020; Fowler-Watt et al., 2020). To stop viruses from spreading, educators and learners cannot meet in person frequently; thus, live and asynchronous online learning and the use of remote conferencing tools such as Zoom and Skype have become primary and indispensable learning modes. MoJos' current learning experiences could be different from those found in the study, and an examination of MoJos' learning experiences in the context of the COVID-19 crisis is needed.

Another finding of the study is that MML is perceived as a promising approach to support MoJos' just-in-time learning during their unpredictable and busy schedules. In the study, MoJos' willingness to learn through a 15-min mobile microlesson significantly predicted their need to develop digital skills with smartphones. Half of the participants indicated that they were willing to spend 4 to 8 min per day on learning a digital skill, and one-fifth of participants were willing to spend 2 to 4 min per day on learning. This result reflects the design principle of MML as each learning unit lasts between 30 s and 5 min, providing short and bite-sized learning contents adapted to small-screen mobile devices (Jahnke et al., 2020). Accordingly, it is possible to have MML as a potential learning approach in mobile journalism education.

There is a limitation in the study that must be noted. The 10 digital skills used as the investigation items were created based on the literature review. However, as the mobile technologies and educational environments are rapidly changing, especially during the COVID-19 pandemic, new emerging skills (e.g., remote interview skills,

virtual newsroom networking, and worldwide collaboration skills) were excluded from the study.

Conclusion

This study provides insights and concrete suggestions for mobile journalism education. Different MoJos have a variety of learning needs related to digital skills with smartphones, such as the need to write better headlines, optimize stories for mobile audiences, and advance their skills in data visualization and VR/AR media editing. The study results indicate that journalism students, educators, journalism professionals, and MCM workers have differing specific needs for digital skills development. Even experienced MoJos require continuous learning. Educational practitioners should consider those learning needs when developing effective learning materials and environments for future mobile journalism training. The MML approach is recommendable because each learning unit is no longer than 5 min, fitting MoJos' busy schedules and meeting their need for just-in-time learning. For the academic research community, future studies are needed to further examine which MML design principles can positively facilitate MoJos' learning and how MML affects MoJos' learning effectiveness and efficiency. In addition, this study has found that MoJos are willing to learn with MML, but the correlation between the level of willingness to learn and the length of time that MoJos learn from the field remains unclear. These knowledge gaps can be topics for future research.

Appendix

The Survey Questionnaire

Question 1 (position): Are you primarily a:

  A. Journalism student
  B. Journalism educator
  C. Professional (Journalist-editor, manager or team leader, and others)
  D. Practitioner (Public relations or public information or communications, marketing specialist, other media-related worker)
  E. None of the above.

Question 2 (gender): What is your gender? (Open-ended question)

Question 3 (years of work experience): How long have you been working in journalism, communications, or media? (Include time teaching.)

  A. Less than 1 year
  B. 1 to 4 years
  C. 5 to 9 years
  D. 10 to 19 years
  E. 20 or more years

Question 4: Rate your training needs for newsgathering using smartphones: (rate on each item by 1 to 5 points, 5 points means the most urgent need):

1. -Shooting video
2. -Editing video
3. -Shooting photos
4. -Editing photos
5. -Recording audio
6. -Editing audio

Question 5: Rate your most urgent training needs for social media (rate on each item by 1 to 5 points, 5 points means the most urgent need):

A. Using social media for reporting
B. Using social media for personal branding and audience engagement
C. Telling stories using Facebook Live
D. Telling stories using Snapchat and Instagram

Question 6: Rate your most urgent training needs for the following (rate on each item by 1 to 5 points, 5 points means the most urgent need):

A. Using audience analytics to drive traffic and inform coverage
B. Writing better headlines for mobile, social and search
C. Presenting stories better for mobile audiences
D. Using data journalism to develop enterprise stories
E. Creating simple graphics, such as maps and charts
F. Telling stories using podcasts

Question 7: What would you or your employer be <u>willing to pay</u> you to master ONE of the skills listed above?

A. Nothing
B. $0.01–$25
C. $26–50
D. $51–75
E. $76–100
F. $101–250
G. $251–500
H. $501 or more

Question 8: What other thoughts do you have about your most urgent need for digital training? (Open-ended question)

Question 9: How interested would you be in a Digital Journalism 101 course that will introduce you to foundational skills, such as these?

A. Set up an RSS feed
B. Listen to podcasts
C. Use the mobile phone as a WiFi hotspot
D. Set up a blog
E. Set up a personal website

Question 10: What other foundational skills would you like to see included in a Digital Journalism 101 course? (Open-ended question)

Question 11: Which has been the most successful way for you to learn digital skills? Pick one.

A. Live online training at set times (such as a webinar) in which you received immediate feedback and interacted with the instructor and other attendees in real-time
B. Asynchronous online training in which you could learn at your own pace at any time but you receive delayed or no interaction with the instructor and other attendees
C. In-person workshop or conference
D. College class
E. Informally from a colleague
F. Taught myself by watching videos or reading
G. None of the above. How?
H. I have not tried yet to learn digital skills.

Question 12: In a few words, please describe why the form of training you selected in Question 8 was successful for you. (Open-ended question)

Question 13: In a few words, please describe what the perfect training method for you would look like. (Open-ended question)

Question 14: In any given week, how much time do you have available to learn new skills?

A. None
B. 1–15 min
C. 16–30 min
D. 31–60 min
E. 61–120 min
F. 121 min or more

Question 15: Assuming it were affordable, how likely would you be to try a course in a digital skill you wanted to learn that was delivered on your mobile phone in 15-min lessons? (Ranking the likely degree)

Question 16: Do you have any other comments you would like to add about skills you would like to learn or how you would like to learn them? (Open-ended question)

Question 17: Would you be willing to participate in an hour-long small-group discussion online so that we can better understand your needs for digitals skills training? You would receive a $25 gift card for participating.

 A. Yes, I am interested. Here is my email address: (Your answers to the survey will not be associated with your email.)
 B. No, thanks

Question 18: Last question: If you want to enter a raffle for a chance to win a $50 Visa gift card, please provide your email below. (Your answers to the survey will not be associated with your email.)

 A. Great, I hope I win! Here's my email
 B. No, thanks.

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References

Abuzid, H. F. T. (2017). Applying QFD tools for quality improvements in curriculum design and teaching strategies to meet with the customer (learner) needs. *Journal of Engineering and Applied Sciences*, *12*(3), 684–669.

Benesty, J., Chen, J., Huang, Y., & Cohen, I. (2009). Pearson correlation coefficient. In *Noise reduction in speech processing* (pp. 1–4). Springer.

Brandenburg, D. C., & Ellinger, A. D. (2003). The future: Just-in-time learning expectations and potential implications for human resource development. *Advances in Developing Human Resources*, *5*(3), 308–320.

Bui, M. N., & Moran, R. E. (2020). Making the 21st century mobile journalist: Examining definitions and conceptualizations of mobility and mobile journalism within journalism education. *Digital Journalism*, *8*(1), 145–163.

Cameron, D. (2009). Mobile journalism: A snapshot of current research and practice. In A. Charles & G. Stewart (Eds.), *The end of journalism: News in the twenty-first century* (pp. 63–72). Peter Lang.

Cervi, L., Pérez Tornero, J. M., & Tejedor, S. (2020). The challenge of teaching mobile journalism through MOOCs: A case study. *Sustainability*, *12*(13), 5307–5322. https://doi.org/10.3390/su12135307

Costello, J., & Oliver, J. (2018). Human resource management in the media. In A. Albarran & B. Mierzejewska (Eds.), *Handbook of media management and economics* (2nd ed., pp. 95–110). Routledge.

Crawford, J., Butler-Henderson, K., Rudolph, J., Malkawi, B., Glowatz, M., Burton, R., . . . Lam, S. (2020). COVID-19: 20 countries' higher education intra-period digital pedagogy responses. *Journal of Applied Learning & Teaching*, *3*(1), 1–20.

Emerson, L. C., & Berge, Z. L. (2018). Microlearning: Knowledge management applications and competency-based training in the workplace. *Knowledge Management & E-learning (KM&EL)*, *10*(2), 125–132.

Fowler-Watt, K., Majin, G., Sunderland, M., Phillips, M., Brine, D., Bissell, A., & Murphy, J. (2020). Reflections on the shifting shape of journalism education in the Covid-19 pandemic. *Digital Culture and Education*. Advance Online Publication. https://www.digital-cultureandeducation.com/reflectionson-covid19/journalism-education

Jahnke, I., Lee, Y. M., Pham, M., He, H., & Austin, L. (2020). Unpacking the inherent design principles of mobile microlearning. *Technology, Knowledge and Learning*, *25*(3), 585–619.

Khikmatova, M. A. (2020). Learner needs analysis and its application in the process of learning foreign languages. *Наука и образование сегодня*, *4*(51), 47–49.

Kitsa, M. (2019). Smartphones in journalism. *Media Literacy and Academic Research*, *2*(2), 94–108.

Knowles, M. S. (1980). *The modern practice of adult education: From pedagogy to andragogy* (Rev ed.). Follett.

Kraft, N., & Seely, N. (2015). Making mojos: How iPads are enhancing mobile journalism education. *Journalism & Mass Communication Educator*, *70*(3), 220–234.

Mabrook, R., & Singer, J. B. (2019). Virtual reality, 360 video, and journalism studies: conceptual approaches to immersive technologies. *Journalism Studies*, *20*(14), 2096–2112.

Maniou, T. A., Stark, A., & Touwen, C. J. (2020). Journalism Training Beyond Journalism Schools. *Journalism & Mass Communication Educator*, *75*(1), 33–39.

Martyn, P. H. (2009). The Mojo in the third millennium: Is multimedia journalism affecting the news we see? *Journalism Practice*, *3*(2), 196–215.

Marymont, K. (2006). *How they did it: Fort Myers "Mojo" journalists search out news at the neighborhood level, identify community contributors*. Gannett's News Watch. https://web.archive.org/web/20080421124521/

Mayring, P. (2004). Qualitative content analysis. *A Companion to Qualitative Research*, *1*, 159–176.

Ooi, S. K. G., Makmur, A., Soon, A. Y. Q., Fook-Chong, S., Liew, C., Sia, S. Y., & Lim, C. Y. (2019). Attitudes toward artificial intelligence in radiology with learner needs assessment within radiology residency programmes: A national multi-programme survey. *Singapore Medical Journal*, *1*, 22. https://doi.org/10.11622/smedj.2019141

Park, M. H. (2009). *Comparing group means: t-tests and one-way ANOVA using Stata, SAs, R, and SPSS*. Centre for Statistical and Mathematical Computing, Indiana University. https://scholarworks.iu.edu/dspace/handle/2022/19735

Salzmann, A., Guribye, F., & Gynnild, A. (2020). "We in the Mojo Community"–Exploring a Global Network of Mobile Journalists. *Journalism Practice*, 1-18. https://doi.org/10.1080/17512786.2020.1742772

Shail, M. S. (2019). Using micro-learning on mobile applications to increase knowledge retention and work performance: A review of literature. *Cureus*, *11*(8), Article e5307. https://doi.org/10.7759/cureus.5307

Thomas, P. A., Kern, D. E., Hughes, M. T., & Chen, B. Y. (Eds.) (2016). *Curriculum development for medical education: a six-step approach*. Johns Hopkins University Press.

Wenger, D., Owens, L., & Thompson, P. (2014). Help wanted: Mobile journalism skills required by top US news companies. *Electronic News*, *8*(2), 138–149.

Wenger, D. H., Owens, L. C., & Cain, J. (2018). Help wanted: Realigning journalism education to meet the needs of top US news companies. *Journalism & Mass Communication Educator*, *73*(1), 18–36.

Westlund, O., & Quinn, S. (2018). Mobile journalism and MoJos. In *Oxford research encyclopedia of communication*. Oxford University Press.

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Appendix 3–Paper 3: Iterative Usability Testing: An Evaluation of a Mobile Microlearning Course

Paper 3: submitted to the *Journal of Usability Study (JUS)*. Not accepted.

Iterative Usability Testing: Formative Evaluation of a Mobile Microlearning Course

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Abstract

Mobile microlearning (MML) is a learning approach wherein learners can receive small chunks of learning resources with their smartphones in specific moments of needs, for example during their daily work practices. A MML platform to support mobile journalists' professional development has been developed. First, a high-fidelity prototype was created, then a three-cycle iterative usability evaluation of the MML platform was conducted. Expert reviews and usability testing with task-based think aloud and observations have been applied and both technological and pedagogical usability heuristics were taken into consideration. Results showed that breaking down learning contents into small pieces of information and fitting them into small screens of mobile devices was a challenge. The presentation of font size, content structures, and the amount of images and texts were important components. In addition, the usability problems identified by users were different from the usability experts. Experts were likely to look at the styling of interface design while users tended to focus on how their actions were affected by these interface elements. It is suggested to include both experts and end users in the usability evaluation process to comprehensively cover design issues. Further discussions and insights are addressed in this article.

Keywords

Iterative usability testing, expert review, mobile microlearning, small screens, pedagogical usability, technical usability, journalism education

Introduction

Mobile microlearning (MML) is a learning approach, and its unique feature is that each lesson takes only 30 seconds to five minutes on average and is displayed on smartphones or mobile devices (Jahnke, Lee, Pham, He, & Austin, 2020). MML focuses on a goal-oriented problem-solving approach and enables users to quickly learn knowledge and practical skills at the moment of need (Jahnke et al., 2020). Because of the mobility and flexibility features, MML can especially be a compelling solution for people outside traditional office environments who often use mobile devices as a medium for their work (Clark & Mayer, 2016; Glahn, 2017).

Mobile journalists (MoJos) are one of the target populations to utilize MML for their workplace training or professional development (Lee, 2021). In the field of journalism, news media have changed from a 24-hours newspaper cycle to a minute-by-minute update mobile and digital format (Costello & Oliver, 2018). Journalists must process and report news as soon as they gather it and synthesize it into a mobile-friendly content (Salzmann, Guribye, & Gynnild, 2020). According to this change in journalism working practice, smartphones have become an important resource which allow journalists to become "mobile" and learn on demand outside of the office with their smartphones on the go (Kitsa, 2019; Westlund & Quinn, 2018). A previous study assessed MoJos' learning needs and indicated that MML is a suggested solution to support MoJos with just-in-time learning because it is able to deliver bite-size learning units which can be effectively absorbed by MoJos (Lee, 2021).

Several mobile application platforms have been developed for delivering micro contents to particular learners in specific topics such as Lynda.com, TalentLMS, Udemy, and WiziIQ and a cohesive design principles were developed (Jahnke et al., 2020), but there is no specific MML course targeting the learning needs of MoJos (Lee, 2021). Besides, literature shows that when designing or developing a mobile microcourse, educators or instructional designers tended to focus on how to break down a set of learning materials into a small piece of information and create short and focused burst multi-media content for the learners. However, learners' user experiences and usability issues when interacting with the MML platform were absent (Chai-Arayalert & Puttinaovarat, 2020; Kumar & Goundar, 2019; Rensing, 2016).

To fill the exploration gap, we worked with journalism professionals and aimed to develop a mobile microlearning platform for MoJos to support their on-demand learning. Given the goal of the study, the main research question (RQ) are as follows:

- **RQ1:** How can a formative usability study reveal key design issues of a mobile microcourse design?
- **RQ2:** What types of usability issues do experts and real end-users (MoJos, students) identify during the design and evaluation of the mobile micro-course?
- **RQ3:** What are the challenges of a usability study practice applying in the design of mobile microlearning?

Related Work

Usability is an important characteristic of learning technologies as it correlates to the added value users perceive while learning with the platform (Zurita, Baloian, Peñafiel, & Jerez, 2019). However, this concept seems to be neglected in the field of mobile microlearning. For example, Chai-Arayalert and Puttinaovarat (2020) developed a mobile microlearning prototype in the field of environmental education, but there was no further usability testing to access the MML platform. Rensing (2016) developed a MML system to support service technicians' situated learning in their workplace practices but did not conduct usability evaluations on the MML platform. Ohkawa et al. (2018) developed a language learning system in a microlearning approach and found that the prototype had certain usability problems relating to interface design. Although they proposed certain solutions to refine the prototype such as visualizing the learning status and adding the function which enabled users to resume activities from an appropriate point, Ohkawa et al. (2018) did not conduct a usability testing to understand the user or learner experience of their system. Given the lack of usability testing in several mobile microlearning designs and development research, this study aimed to fill this gap and conduct usability testing for a mobile microcourse.

In this work, usability is defined as "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use" (ISO, 1998, Part II 9241-11 standard; Sauro & Lewis, 2016). Effectiveness is the accuracy, completeness, and appropriateness with which target users can achieve specific goals and accept the designs in a particular environment. Efficiency means the resources that are expended to achieve a specific goal such as the time on completing a specific task. Satisfaction is users' positive or negative attitudes, emotions, and physiological status related to the use of a system or product (Bevan, Carter, & Harker, 2015). These three components were mainly applied as a foundation to support the usability testing of mobile microcourse.

In addition, during the iterative usability testing, two evaluation dimensions were suggested (Nokelainen, 2005; Zurita, Baloian, Peñafiel, & Jerez, 2019):

- **Technological usability:** the degree to which learners can easily and efficiently use a learning application to satisfy their goals and requirements.
- **Pedagogical usability:** users' perceptions on the application, contents, and tasks which could be supported in their learning process in a specific learning context.

The representative technological usability heuristics set was proposed by Nielsen (1994) and the classical pedagogical usability heuristics set was addressed by Nokelainen (2005, 2006). The components of the technological and pedagogical usability criteria are specified in Table 1.

Table 1. Technological and Pedagogical Usability Heuristics

Technological Usability (Nielsen, 1994)	Pedagogical Usability (Nokelainen, 2006)
1. Visibility of system status.	1. Learner control.
2. Match between the system and the real world.	2. Learner activity.
3. User control and freedom.	3. Cooperative learning.
4. Consistency and standards.	4. Goal orientation.
5. Error prevention.	5. Applicability.
6. Recognition rather than recall.	6. Added value for learning.
7. Flexibility and efficiency of use.	7. Motivation.
8. Authenticity and minimalism in design.	8. Valuation of previous knowledge.
9. Recognition, diagnosis, and recovery from errors	9. Flexibility.
10. Help and documentation.	10. Feedback.

Methods

This study applied a formative educational design research study (McKenney & Reeves, 2019) in which we designed and developed an online mobile microcourse in several iterations with different methods (see below). In each iteration, there was expert-data or user-data to be collected to inform the microcourse improvement.

Study Design Structure and Iterative Steps

An iterative usability testing (Nielsen, 1993) was conducted over three sequential iteration stages between August and October, 2017 to evaluate the design of the mobile microcourse. Because certain usability problems may fail to identify during a one-time evaluation, a formative study approach could maximize the evaluations as soon as we detect and understand the problems in each testing stage, and we are able to change and improve the design accordingly (Sauro & Lewis, 2016).

In the study, a multidisciplinary research team had weekly in-person and virtual meetings to reflect each testing process (Hakoköngäs & Asiala, 2020) and consisted of experts in Journalism education and user interface and usability research, as well as learning technologies design, and the project manager. In the **design phase**, a high-fidelity version of the mobile microcourse

had been created in previous work, named "The 5 Cs of writing news for mobile audiences" and supported by a mobile learning application (EdApp). The microcourse consisted of the login page, the start page, a course navigation menu, and the five microlesson sessions (5Cs), Be Conversational, Be Contextual, Be Concise, Be Considerate, and Be Chunky. The objective of this MML platform was to facilitate MoJos' learning process in writing appropriate news headlines and news stories for mobile news readers. The detailed instructional sequence of the 5Cs mobile microcourse was presented in previous work (Lee, Jahnke, Austin, 2021). To ensure the course designed on the concept of mobile microlearning, specific design principles were applied, for example (Jahnke et al., 2020):

- Cues (a-ha moments) to showcase the relevance of the topic
- Concise and snackable materials for a single topic
- Interactive content with diverse media formats such as graphic, animations, text-based multiple choices
- Activity-based short exercises in forms of quizzes or other gamified activities
- Instant feedback box
- Push notifications
- Dashboard and relevant functions allowed users to track learning progress
- Browsable, independent, and searchable navigation menu.

Figure 1 gives an overview of the design steps and iterations. In the **preparation stage**, the research team collaborated with an expert of journalism education generating a potential list of the participants and creating a test execution time frame. The study started participants recruitment after receiving the University Institute Review Board approval. In the **first iteration phase (Iteration 1),** an expert review (Hollingsed & Novick, 2007; Nielsen, 1994) was conducted for the evaluation of initial design problems of the mobile microlearning interface, including technical and pedagogical usability issues. After completing the first-round expert review, the research team analyzed the results and worked together to have an initial refinement of the course. During the same time, a usability testing protocol, a set of follow-up interview questions, an observation sheet for the test, and the testing schedule were prepared for later testing. In the **second Iteration phase (Iteration 2)**, an expert review was conducted again with the revised microcourse and results were analyzed by the research team. The research team refined the course again according to the experts' comments and suggestions and had the revision ready for the third-round iteration. In the **third Iteration phase (Iteration 3)**, a usability testing was conducted to understand users' perceptions and learning experiences with the revised 5Cs microcourse. A series of data analyses was conducted after each phase of iterations and research team had discussion and course refinement accordingly.

August–September 2017						
13	14	---	---	---	Sep 8	Sep 9
Design Phase A high-fidelity prototype of a mobile microcourse						

September 2017						
10	11	12	13	14	15	16
Preparation Stage				**Iteration 1** Expert Review		
17	18	19	20	21	22	23
Data analysis, course refinement, & completion of an improved prototype				**Iteration 2** Expert Review		
24	25	26	27	28	29	30
Data analysis, course refinement, & completion of a ready to go course design						

October 2017						
1	2	---	---	---	13	14
Iteration 3 Usability Testing for two weeks						
15	16	17	18	19	20	21
Data analysis, final course refinement, & completion of a revised and improved MML course						

Figure 1. The study timeline and iterative testing structure.

Participants

A purposive sampling method was used with a maximum variation sampling approach (Etikan, Musa, & Alkassim, 2016) to select target users across a broad spectrum so that to assess the mobile microcourse from all available angles. For recruiting the participants, the inclusion criteria of the experts in the Iteration 1 and 2 stages targeted someone who had two or more years of experience in the field of user experience and usability study, human computer interaction, information experience, and learning technologies. The participants in the Iteration 3 stage had to major in journalism or at least one year of experience engage in the field of journalism. Volunteers from the journalism school who enrolled in a media editing course were recruited in the study and joined in an in-person usability testing. Participants received additional course credits as compensation. A consent form and the introduction of the research purpose had been sent via email and informed consents were received from the participants prior to the testing.

Data Analysis

Experts' feedback was summarized into main suggestions. The research team worked together to determine the adjustments of features and functionalities according to the feedback and a revision of the 5Cs microcourse was ready for the next stage of usability evaluation. Quantitative data (closed questions with Likert scales) were analyzed by SPSS statistics software (Park, 2009). Qualitative data (open-ended questions) were analyzed using the content analysis method (Mayring, 2004).

Results

Three iterative evaluation with two rounds of expert reviews and one usability testing were conducted to refine the 5Cs mobile microcourse. In summary, two experts identified five initial usability problems in the stage of Iteration 1, another two experts proposed three minor usability issues in the stage of Iteration 2, and five users and their usability testing observers identified total number of 12 usability issues in the stage of Iteration 3. The average time length from the completion of an evaluation stage to the implementation of the mobile microcourse revisions by the research team was 13 days. The data collected from all evaluation stages had been analyzed and results were presented in the following sections.

Iteration 1

Execution Background

In Iteration 1, the study conducted an initial expert review to evaluate the system usability, correctness, consistency, and completeness throughout the entire MML course. Two user experience and usability design experts both of whom were female participated in the first-run evaluation and they used their own smartphones to download the course. On average, the participants had three or more years of professional experience as an UX and usability professionals and spent most of their time at work on usability and learning technologies-related research. The review was conducted individually. Because the UX and usability experts knew and understood the heuristics, they did take the heuristics into consideration but were not required to follow an explicit set of rules to each potential problem. Expert review results were analyzed and synthesized into main suggestions. The research team worked together to discuss the revision.

Results

In Iteration 1, five usability issues were initially identified by the experts with improvement recommendations, including four technical issues and once pedagogical issues.

First, the content displayed on mobile screen did not totally fit in Problem #1. An expert indicated that when viewing the content on the bigger screen (e.g., laptop and desktop), the text were very clean and readable. But when applying iPhones to review the questions, the expert noticed that some of the contents/sentences displayed on the interface were overlapped. See the screenshot of Problem#1 in Figure 2.

Figure 2. An example of the screenshot to indicate Problem #1.

Second, an expert indicated that too many contents shown on the mobile interface at once (Problem #2). It was not easy to read on a mobile screen. The expert addressed that, because the mobile screen size had limited space to present the content, the design principle is not the same as the design for the computer screen. It is suggested to be clean and simple for mobile interface design. Because the users knew "The 5C's of writing news for mobile audiences" was the main topic of the course, the expert suggested to remove this title so that the interface could be clean and simply indicate the instruction. See the screenshot of Problem#2 and its revision in Figure 3.
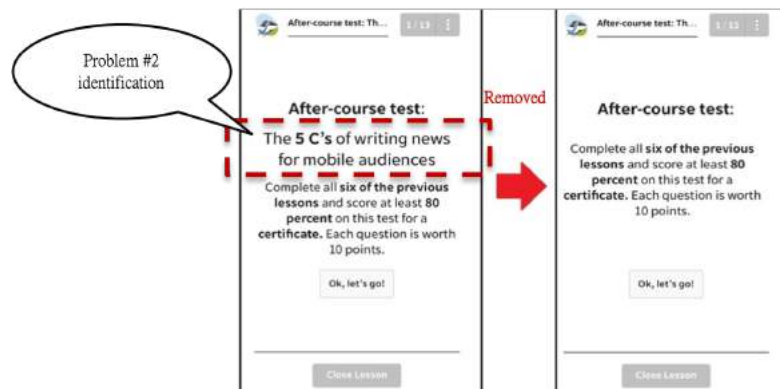
Figure 3. An example of the screenshot to indicate Problem #2 and its revision.

Third, the expert addressed the inconsistent font-sizes of texts displayed in the screen (Problem #3) and this might increase the user's reading load. The expert's suggestion was to make all the texts with the same font-size and "bolded" the important texts as the design made to catch the user's attention. See the screenshot of Problem#3 and its revision in Figure 4.
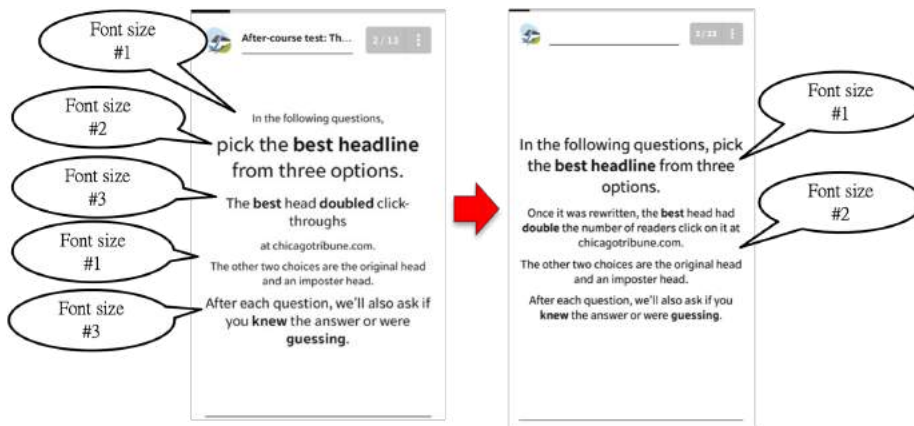

Figure 4. An example of the screenshot to indicate Problem #3 and its revision.

Fourth, one expert found that the learning feedback did not show all the correct and incorrect answers on the screen when completing a short exercise (Problem #4).The expert assumed that users might want to see the incorrect options again comparing with the correct one and feedback. Thus, the expert suggested to include all the correct and incorrect answers and descriptions in the feedback session which was better than only showing the right answer.

Lastly, the expert indicated that the feedback box blocked a part of the original question option in an exercise section. The expert mentioned that there was no problem to view the contents of instant feedback on the bigger screens. But when switching to the mobile screen, the instant feedback blocked a part of the original options. It is suggested to reduce the words of the contents and remove the scroll bar from the interface as it made the interface look like disorganized. See the screenshot of Problem#5 and its revision in Figure 5.
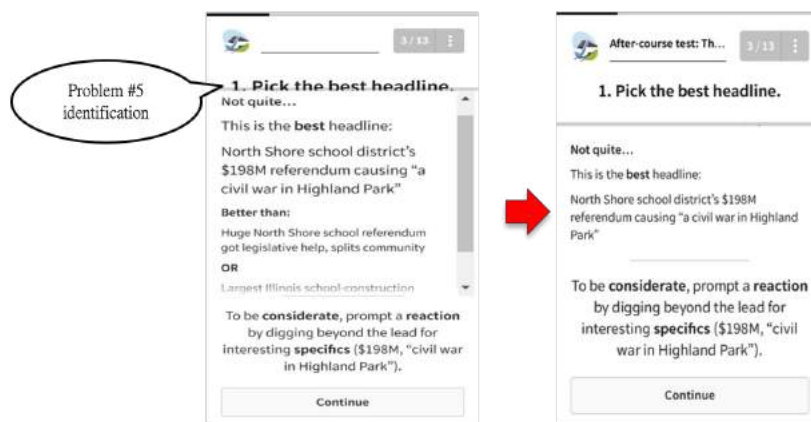

Figure 5. An example of the screenshot to indicate Problem #5 and its revision.

Iteration 2

Execution Background

According to the refined version of the 5Cs microcourse, two experts were recruited in the stage of Iteration 2 to separately evaluate the microcourse design using their own smartphones. One female expert was an academic faculty who possesses nine years' experience in the human-computer interaction and information experience area and the other male reviewer has two years of professional experience as a learning technologies expert. Results were generalized into concrete improvement recommendations and the research team worked together again to refine the 5Cs microcourse accordingly.

Results

Three problems were identified in Iteration 2 expert review, including one technical issues and two pedagogical usability issues.

First, the learning progress bar did not catch up learners' process and showed incorrect learning status (Problem #1). The expert mentioned, "Once I'm done with the 'be conversational' lesson, the progress bar only shows I have completed 80% of the lesson but at the same time saying the lesson is complete. I find it's misleading and didn't know what to do next." It is suggested to make sure the progress bar correctly connect to the users' learning process. Second, the expert perceived that the drag-n-drop exercise was too easy for the journalists to build up their professional skills (Problem#2). It is suggested to design for higher-lever skills such as

analyzing or creating a news headline by using the drag-n-drop exercise but not only drag the words to form a headline. Otherwise, the expert said that, "I feel like it's just an activity for new learners of English to learn how to construct a sentence." Lastly, the expert indicated the instruction of the "crossing out words" exercise was confusing (Problem #3) and suggested rewording the instruction and making sure the information presented were understandable.

In Table 2, the problems identified in the stage of Iteration 1 and Iteration 2 were listed with improvement recommendations.

Table 2. Problems and suggestions identified by experts in iteration 1 & 2 evaluation

Iterative 1 Expert Review			Iterative 2 Expert Review		
Usability Heuristic	**Problem(P)**	*Suggestion*	**Usability Heuristic**	**Problem(P)**	*Suggestion*
Technical-*Minimalism in design*	**P1:** The content displayed did not totally fit in the mobile screen	*Condense the contents and be aware of the margin displayed on small screens of mobile devices*	Technical-*Visibility of system status*	**P1:** Learning progress bar did not catch up learners' actual learning process and showed incorrect learning status	*Make sure the progress bar correctly connect to users' learning process.*
Technical-*Minimalism in design*	**P2:** Too many contents shown on the mobile interface at once. It is not easy to read on small screen	*Remove the title so that the interface can be clean and simply indicate the instruction for the after-course test.*	Pedagogical-*Added value for learning*	**P2:** The difficulty level of the drag-n-drop exercise was too easy for the target users	*There should be more words than needed for learners to drag the words to build up a news headline*
Technical-*Consistency*	**P3:** The inconsistent font-sizes of texts displayed in the screen. It might increase the user's reading load	*Make all the texts with the same font-size and "bold" the important texts as you made to catch the user's attention.*	Pedagogical-*Applicability*	**P3:** "crossing out words" exercise was confusing	*Check out if instructions was clear, make sure information and images presented on screen were intelligible*
Technical-*Error prevention*	**P4:** The feedback box blocks part of the original question options	*Condense the text and remove the scroll bar to make the interface clean*			
Pedagogical-*Feedback Presentation*	**P5:** Learning feedback did not show all the correct and incorrect answers	*Include all the answers in the feedback, add a small scroll bar to include all the answers*			

Iteration 3

Execution Background

A usability testing was conducted in Iteration 3. Five female journalism students volunteered to participant in the study. In the beginning of the test, participants needed to complete a pre-test survey for identifying their demographic information. Participants then started downloading the mobile learning App, EdApp to their own smartphones and navigating through the five microlessons one by one. A think-aloud method was applied to ask participants to describe their actions and thoughts during the process. A short after-lesson survey was shown on the app screen after the participants completed each lesson. Participants were asked to complete the survey about their perceptions of the lesson length and the lesson's level of difficulty. After the five learning sessions, the participants completed a post-test survey for their perception when learning with the mobile microcourse. A trained operator had a follow up interview with the participants to further understand their feedback and comments about the course structure and the system design. A trained operator introduced the testing purpose and the execution procedure to the participants and another research team member was an observer was responsible for observing the participants' performance with the 5Cs microcourse, including their performance, oral and physical behavior expressions, etc. The testing process were audio recorded.

The usability testing results were presented in two sections, including 1)user experiences of the mobile microcourse regarding the effectiveness, efficiency, and satisfaction, 2) usability problems identified by the users and observations and recommendations (Table 3).

Effectiveness

All the participants positively learned new knowledge after the course (Table 3). Results showed that two out of the five users (40%) "Strongly Agree" that they learned new things after the 5C's micro-course and another three testers (60%) "Agree" they learned new things after the lessons. The average score was 4.4 points based on a 5-points Likert scale ranged from "Strongly Disagree (scored =1 point)" to "Strongly Agree (scored =5 points)."

Efficiency

A short survey after each lesson asked the users about their perceived lesson length, scoring options "Too long" coded= 3 points, "About right" by 2 points, and "Too short" by 1 points, and lesson's difficulty level, scoring "Too hard" coded= 3 pints), "About right" by 2 points, and "Too easy" by 1 point.

Results in Table 3 shows that, overall, the lesson length and lessons' difficulty level were about right, both average scores were 1.98 points. In terms of each lesson (Be conversational, Be considerate, Be concise, Be contextual, and Be chunky):

- Be Conversational: It is about the right length and about right difficulty level indicated by all the users (100%).
- Be Considerate: Three out of the five users (60 %) indicated the lesson length was about right, one user (20%) addressed too long and one user (20%) addressed too short . For the difficulty level of lesson, four users (80%) indicated it was about right and one user (20%) addressed it was too easy.
- Be Concise: It is about the right length indicated by all the users (100%). For the difficulty level of lesson, four users (80%) indicated it was about right and one user (20%) addressed it was too easy.
- Be Contextual and Be chunky sessions: Four users (80%) indicated it was about right about the lesson length and one user (20%) addressed it was too short, and it was about right on the difficulty level indicated by all the users (100%).

Satisfaction

All the participants' positively perceived interests in the course exercises (Table 3). Three out of the five users (60%) "Strongly Agree" that the 5Cs' course exercises made learning fun and the other two users (40%) "Agree" with this point, and the average score was 4.5 points based on

the after-course survey question "The exercises in the course made learning fun." with the same 5-points Likert scale.

All participants (100%) "Strongly Agree" to recommend this course to journalists who want to learn how to write news for mobile audiences. Information was retrieved from the results of after-course survey question "Would you recommend this course to journalists who want to learn how to write news for mobile audiences?" In terms of the rationales of how the users wanted to promote the mobile microcourse to others, the responses are listed below:

> The interaction between the course and students is great. (User #1)

> It was engaging and entertaining, but not great if you need personal interaction in order to ask questions, etc. (User #2)

> It's fast and easy to follow along. (User #3)

> I would say it's useful to put yourself in the perspective of the reader based on prompts so you can see which stories you would click on if you were them. (User #4)

> It's quick and painless, but it helps you recognize and learn some things to help your writing. (User #5)

Detailed scoring results of users' perceptions relating the effectiveness, satisfaction, and efficiency (i.e., lesson length and lesson's difficulty level) of mobile microcourse are shown in Table 3.

Table 3. Users' perceptions when learned with the mobile microcourse identified in the post-test survey

Usability Components	User experience	U1	U2	U3	U4	U5	Ave. score
Effectiveness	Overall, I positively learned new knowledge after the course	4	5	5	4	4	4.4
Satisfaction	Overall, I positively perceived interests in the course exercises	4	5	5	4	5	4.6
	I had Intention to recommend this course to other journalists	5	5	5	5	5	5
Efficiency	Perceived (lesson length|lesson difficulty level) in Lesson 1	2 | 2	2 | 2	2 | 2	2 | 2	2 | 2	2 | 2
	Perceived (lesson length|lesson difficulty level) in in Lesson 2	1 | 1	3 | 2	2 | 2	2 | 2	2 | 2	2 | 1.8
	Perceived (lesson length|lesson difficulty level) in Lesson 3	2 | 2	2 | 2	2 | 2	2 | 1	2 | 2	2 | 1.8
	Perceived (lesson length|lesson difficulty level) in Lesson 4	2 | 2	2 | 2	1 | 2	2 | 2	2 | 2	1.8 | 2
	Perceived (lesson length|lesson difficulty level) in Lesson 5	2 | 2	2 | 2	1 | 2	2 | 2	2 | 2	1.8 | 2
Ave. Score of Lesson length| Difficulty Level							1.98|1.98

Note. "U" means the user in the test. (1) Scoring on Effectiveness and Satisfaction: A 5-points Likert scale ranged from "Strongly Disagree (coded=1 point)," "Disagree (2 points)," "Neutral (3 points)," "Agree (4 points),"and "Strongly Agree (5 points)." (2) Scoring on Efficiency: "Too long (coded= 3

points),""About right (2 points), " "Too short (1 point)." scoring method of lesson difficulty level: "Too hard (3 points),""About right (2 points), " "Too easy (1 point)."

Results-Usability Problems and Improvement Recommendations

Overall, all the users indicated there was no difficulty with installing the Ed. mobile app. The users asked about their impressions of the mobile microcourse platform in the follow up interview session based on questions "What worked well for you in this lesson?" The users mentioned that the course was easy to understand and follow. Multiple ways to present the learning materials such as visualized images and examples, interactive activities (e.g., discussion boards) and game-based exercises (e.g., swiping or drag-n-drop answer response) were positive impression indicated by the users. For example, the users mentioned:

> *I like the swipe session and it makes me reflect how much knowledge I get the hang of. (User #1)*

> *I liked the different ways of choosing the best headline: multiple choice, writing, creating it using given words. The variety and the ability to earn stars with a right answer made me want to do well. It was challenging but fun. (User #5)*

The users proposed certain concerns relating to the mobile microcourse based on the after-course survey question "Identify the biggest concern you have about the course." The users' comments are listed below:

> *If people needed to ask questions or talk to other students, this isn't the course for them. (User #2)*

> *Takes away the conversation that we have in class about each lesson. If I disagree with an answer, there's no way to voice that disagreement? (User #3)*

> *"The various types of activities that involve scrolling and tapping and timers and comments. I think there may be too many types and the user may get frustrated trying to figure out each thing. But a few types provides good variety when going through the lessons. (User #5)*

Based on the observations, the observers indicated that users perceived the mobile microcourse had a clear organization which was quick and easy to follow. The interactivity was great and a variety of activities were fun but not complicated. Table 4 summarizes the observation results.

Table 4. Observation results indicated by the trained observers

Comments and Problems	U1	U2	U3	U4	U5
App Install easy	V	V	V	V	V
Too much Text, needs text arrows, doesn't know where to click	V	V		V	V
Word Scramble activity was confusing	V	V	V	V	
The users liked the games but found directions a bit confusing			V	V	V
Crossing Out activity was confusing		V			
The users liked swiping activity			V	V	
Too much text and images	V	V			
Circling and tapping issues				V	

Note. "U" means the user in the test. "V" means comments or problems identified.

An overview of the users and observers' usability problem identification, Table 5, summarizes 12 comments and problems that identified by the users and observers in the stage of Iteration 3, including five technical usability issues, three pedagogical issues, and four technical and usability issues. Improvement recommendations were also listed.

Looking deeply into the results, seven out of the 12 problems (58%) were commonly proposed, while five out of 12 problems (42%) were differently proposed by the users and observers. For

example, in the session of technical usability issue, observers targeted on the issue that some acronyms shown in the course went away too fast and certain weird circle images displayed in texts which should be fixed, while the users concerned about the font size issues. In the session of pedagogical issue, the users additionally indicated that the preview of other learners' answers in an exercise might affect their responses and suggested to show other learners' answers after they completed the exercise. Furthermore, the users also commented that the times-activity was too short to catch up and this issue made them stressful.

Lastly, aligned with the proposed problems and improvement suggestions, the research team completed the final refinement of the 5Cs mobile microcourse and provide practical recommendations for future usability study of MML in the discussion section.

Table 5. Usability problems and recommendations identified by users and observers

Usability Heuristic	Problems	Users	Observers	*Recommendations*
Technical Approach				
Error prevention	**P1:** App easy to install	V	V	*No changes needed*
Error prevention	**P2:** Some tapping and circling functionality issues	V	V	*Refine these two functions*
Recognition rather than recall	**P3:** Some acronyms shown in the course went away too fast so that users did not memorize and didn't think it would be necessary		V	*Reinforce the importance of acronyms when it first appears. Extend the time that texts display on the interface*
Error prevention	**P4:** Weird circle images in text		V	*Upload a new one.*
Efficiency of use	**P5:** Some texts can have bigger size.	V		*Refine the font size*
Minimalism in design	**P6:** Too much text and images. User feels slide is visually overwhelming.	V	V	*Provide users a less cluttered page. Remove redundant words and unnecessary information*
Total number of identified problems		**4**	**5**	
Pedagogical Approach				
Learner control.	**P7:** In the beginning, the users was uncertain if there was a dragline to swipe down or not.	V	V	*Rewrite the instructions for the timed swiping game and further explain how the sliding bar works.*
Learner activity	**P8:** Word Scramble activity was confusing	V	V	*Remove redundant words to make the instruction more concise*
Learner activity	**P9:** Instructions of the crossing out activities were vague	V	V	*Add more clear instructions on how to answer the crossing out activities was*
Learner control & Flexibility	**P10:** The original instructions of some exercises did not show up while users were typing their answers	V	V	*Keep the original text on the interface to users' reference while typing their own answers.*
Learner activity & Feedback	**P11:** When the Option came to write my own headline, the users could see what other people put	V		*It would be nice to see others responses, but maybe after I gave my input instead of before.*

	before they wrote anything and they think it influenced what I came up with.			
Added value for learning	**P12:** The times-activity was short that made the users felt stressful so that have not enough time to read the instruction and complete the activity	V		*Extend the time on the activity and provide a clearer and more concise instruction*
Total number of identified problems		**6**	**4**	

Discussion and Recommendation

The main goal of the iterative user experience testing was to identify potential design problems of the mobile microlearning platform that could be encountered by learners in the field of journalism education. Aligned with the research questions, the study addressed three critical points for further discussion as follows.

Key usability issues identified in the design of mobile microlearning (RQ1)
The 5Cs' mobile microcourse had been designed based on a set of MML design principles (Jahnke et al.,2020), while several usability issues were still identified in this iterative usability testing. This finding verified the concerns addressed in previous literature that many mobile microlearning platforms and microlearning materials had been created to smartphone apps and applied in several learning domains, however, usability testing for these MML platforms is usually absent but plays a crucial role for the identification of users' experiences (Chai-Arayalert & Puttinaovarat, 2020; Rensing, 2016). In addition, when interacting with the 5Cs microcourse, the study found that there was an inseparable connection between pedagogical and technical usability, including nine pedagogical usability issues and eleven technical usability issues. Because MML is a blend of two designs of mobile technology and instructional method, the design of mobile technology and its affordances can affect the instructional method as well as in the other way round (Lee et al., 2021). Thus, it is suggested for future usability research in a mobile microlearning approach to take both pedagogical and technical usability issues into consideration.

Importance of the real user involvement-perceptions between users and experts (RQ2)
In the study, results found that experts and the users not only proposed common usability issues but also indicated different perspectives on certain design problems. For example, both experts and the users indicated the font size issues to the mobile microcourse, but experts mentioned the need of making the font size be consistent (Problem#1in Iteration 1) while the users addressed the need of bigger font size in order to easily read contents on a small screen (Problem#5 in Iteration 3). In addition, experts and the users both identified issues on the timed activity, but experts concerned about the content materials of the activity were too easy to cultivate users' professional skills (Problem#1 in Iteration 2) while the users perceived the time to display the activity instruction was too short to read and the time on completing the activity was too short to put in their own answers (Problem # 12 in Iteration 3).

It is noteworthy to know that experts' viewpoints tended to propose problems relating to the interface design and focused on what things look like (e.g., the visual styling of specific interface elements, fonts, page layouts, graphic images, buttons, and navigation menus). Users' experiences in the usability testing were mostly focused on issues relating to interaction design; how they interacted with those specific design elements and how the design affected their actions to achieve their needs and goals. Accordingly, it is concluded that a blended application combining an expert review method and a real-user usability testing was able to explore potential usability issues from diverse angles and perspectives.

Usability challenges in designing microlearning into small screen mobile devices (RQ3)
Several problems regarding the design for small screens were identified in the study. For instance, too much information presented on a small screen at once could lead to the problem

of overlapping every sentence on the interface (Problem #1 & #2 in Iteration 1); inconsistent font type could mess up the presentations, by consequent, the content became disorganized (Problem #3 in Iteration 1); the scrolling bar could be annoying when the space was not enough to fit in all the materials (Problem #4 in Iteration 1); too much text and images presented in the course made users visually overwhelmed (Problem #6 in Iteration 3). These identified problems raise the importance to rethink how to condense the contents into a small screen of smartphones but still delivering meaningful learning information for learners (Zurita, Baloian, Peñafiel, & Jerez, 2019). As Kumar and Goundar (2019) and Joyce, Lilley, Barker, and Jefferies (2016) addressed, developing learning content with mobile technologies is not an easy task because of the limitation of small screen size. Accordingly, it is suggested that a major emphasis in designing for small screens of mobile devices can be the content structures and organizations.

Lastly, the study had a limitation that needs to be considered. Though the study applied a purposive sampling method, five users were journalism students who volunteered to participate in this usability. The data collection and analysis results in the third round iteration could only represent the user experiences of journalism students but not all types of journalists such as mass communication and media workers and professionals. Future study is needed to include a diversity of sample populations in the field of journalism in order to ensure the design of the mobile microlearning platform is easy to use and understandable to the entire target population.

Conclusion

This article proposed a three-stage iterative usability testing and identified both technical and pedagogical usability issues to the mobile microlearning platform. The problem relating to the minimalism in design for small screens of mobile devices was especially identified. In addition, the study found that blended with an expert review method and an usability testing could collect different perspectives from the experts and the real users. Experts tended to focus on what interface elements look like while the real users were mostly concerned about how they interact with these elements. Hence, it is recommended to apply blended usability methods to obtain multidimensional issues and potential problems relating to the learning platform.

Tips for User Experience and Usability Practitioners:

The following advice is based on what the research team considered most noteworthy based on the iterative evaluation study of two-round expert reviews and a usability testing and the analysis of the results:

- Designing for the usability execution timeline and testing protocol: all of the key stakeholders, such as experts of the testing subject, usability researcher, system designers and developers, should be part of the process.
- Coordinating each usability testing: a reminder email or a phone call to the participants should be done one day before the test to ensure the testing will not be delayed according to the participant absence issue.
- Analyzing the usability testing data for a leaning platform: both pedagogical and technical usability heuristics should be taken into consideration.
- In the context of an iterative usability testing, the research team should meet together to discuss the testing results and revision in each iteration cycle before the next round starts.

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References

Bevan, N., Carter, J., & Harker, S. (2015, August). ISO 9241-11 revised: What have we learnt about usability since 1998?. In *International Conference on Human-Computer Interaction* (pp. 143-151). Springer, Cham.

Chai-Arayalert, S., & Puttinaovarat, S. (2020). Designing Mangrove Ecology Self-Learning Application Based on a Micro-Learning Approach. *International Journal of Emerging Technologies in Learning (iJET)*, *15*(11), 29-41.

Clark, R. C., & Mayer, R. E. (2016). *E-learning and the science of instruction: Proven guidelines for consumers and designers of multimedia learning*. john Wiley & sons.

Costello, J., & Oliver, J. (2018). Human Resource Management in the Media. *Costello, J. and Oliver, JJ (2018). Human Resource Management in the Media. Handbook of Media Management and Economics (Media Management and Economics Series)*, 95-110.

Etikan, I., Musa, S. A., & Alkassim, R. S. (2016). Comparison of convenience sampling and purposive sampling. *American journal of theoretical and applied statistics*, *5*(1), 1-4.

Glahn, C. (2017). Micro learning in the workplace and how to avoid getting fooled by micro instructionists—Christian Glahn. https://lo-f.at/glahn/2017/06/micro-learning-in-the-workplace-and-how-to-avoid-getting-fooled-by-micro-instructionists.html

Hakoköngäs, E., & Asiala, A. (2020). Image of the Human in Service Design: An Interview-Based Case Study. *Journal of Usability Studies*, *15*(2), 71–84.

Hollingsed, T., & Novick, D. G. (2007, October). Usability inspection methods after 15 years of research and practice. In *Proceedings of the 25th annual ACM international conference on Design of communication* (pp. 249-255).

ISO (1998). 9241-11. Ergonomic Requirements for Office Work with Visual Display Terminals (VDTs). Part 11: Guidance on Usability. https://www.iso.org/standard/16883.html

Jahnke, I., Lee, Y. M., Pham, M., He, H., & Austin, L. (2020). Unpacking the inherent design principles of mobile microlearning. *Technology, Knowledge and Learning*, *25*(3), 585-619.

Joyce, G., Lilley, M., Barker, T., & Jefferies, A. (2016). Mobile application usability: heuristic evaluation and evaluation of heuristics. In *Advances in human factors, software, and systems engineering* (pp. 77-86). Springer, Cham.

Kitsa, M. (2019). Smartphones In Journalism. *Media Literacy and Academic Research*, *2*(2), 94-108.

Kumar, B. A., & Goundar, M. S. (2019). Usability heuristics for mobile learning applications. *Education and Information Technologies*, *24*(2), 1819-1833.

Lee, Y. M. (2021). Digital Skills of Mobile Journalists: Exploring Learning Needs and Learner Experiences of Just-in-Time Learning With Smartphones. *Journalism & Mass Communication Educator*, 10776958211001692..

Lee, Y. M., Jahnke, I., & Austin, L. (2021). Mobile microlearning design and effects on learning efficacy and learner experience. *Educational Technology Research and Development*, 1-31.

Mayring, P. (2004). Qualitative content analysis. *A companion to qualitative research, 1*(2), 159-176..

Nielsen, J. (1994, April). Usability inspection methods. In *Conference companion on Human factors in computing systems* (pp. 413-414).

Nokelainen, P. (2005, June). The technical and pedagogical usability criteria for digital learning material. In *EdMedia+ Innovate Learning* (pp. 1011-1016). Association for the Advancement of Computing in Education (AACE).

Nokelainen, P. (2006). An empirical assessment of pedagogical usability criteria for digital learning material with elementary school students. *Journal of Educational Technology & Society*, *9*(2), 178-197.

Ohkawa, Y., Kodama, M., Konno, Y., Zhao, X., & Mitsuishi, T. (2018, May). A study on UI design of smartphone app for continuous blended language learning. In *2018 5th International Conference on Business and Industrial Research (ICBIR)* (pp. 584-589). IEEE.

Park, M. H. (2009). Comparing group means: t-tests and one-way ANOVA using Stata, SAs, R, and SPSS. Centre for Statistical and Mathematical Computing, Indiana University. https://scholarworks.iu.edu/dspace/handle/2022/19735

Rensing, C. (2016, July). A context aware learning application for communities of service technicians. In *2016 IEEE 16th International Conference on Advanced Learning Technologies (ICALT)* (pp. 77-81). IEEE.

Salzmann, A., Guribye, F., & Gynnild, A. (2020). "We in the Mojo Community"–Exploring a Global Network of Mobile Journalists. *Journalism Practice*, 1-18.

Sauro, J., & Lewis, J. R. (2016). *Quantifying the user experience: Practical statistics for user research*. Morgan Kaufmann.

Westlund, O., & Quinn, S. (2018). Mobile journalism and MoJos. In *Oxford Research Encyclopedia of Communication*. Oxford University Press.

Zurita, G., Baloian, N., Peñafiel, S., & Jerez, O. (2019). Applying pedagogical usability for designing a mobile learning application that support reading comprehension. In *Multidisciplinary Digital Publishing Institute Proceedings* (Vol. 31, No. 1, p. 6).

Appendix 4–Article 4: Mobile Microlearning Design and Effects on Learning Efficacy and Learner Experience

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DEVELOPMENT ARTICLE

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Mobile microlearning design and effects on learning efficacy and learner experience

Yen-Mei Lee[1] · Isa Jahnke[1] · Linda Austin[2]

Abstract

Mobile microlearning platforms have increased over the years. Literature shows that platforms use specific instructions or media, such as videos or multiformat materials (e.g., text, audio, quizzes, hands-on exercises). However, few studies investigate whether or how specific design principles used on these platforms contribute to learning efficacy. A mobile microlearning course for journalism education was developed using the design principles and instructional flow reported in literature. The goal of this formative research was to study the mobile microcourse's learning efficacy, defined as effectiveness, efficiency, and appeal. Learners' knowledge before and after the mobile microcourse was analyzed using semistructured questionnaires as well as pretests and posttests to measure differences. The results indicate that learners of this mobile microcourse had an increase in knowledge, more certainty in decisions about practical applications, and an increase in confidence in performing skills. However, automated feedback, timed gamified exercises, and interactive real-world content indicate room for improvement to enhance effective learning.

Keywords Microlearning · Instructional flow · Microcourses · Mobile devices · User experience · Learning efficacy

Introduction

Mobile microlearning (MML), first mentioned in 2012, is evolving as an emerging practice in corporate training and workplace learning (Callisen 2016; Clark et al. 2018). Mobile microlearning (mobile micro-learning or micro learning) offers a new way to learn on the small screens of portable devices with bite-size steps and small units of information

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(Giurgiu 2017). Different from traditional online learning environments, such as Canvas or Moodle, mobile microlearning focuses on the learning process by chunking the learning material into smaller units, each teaching a single concept, and each learning unit lasting no longer than 5 min (Khurgin 2015; Nikou and Economides 2018a).

Mobile microlearning targets the mobility and flexibility of learners who use the small screen of portable technologies (e.g., smartphones) to learn anytime and anywhere in an informal manner, such as while waiting in a line for coffee or while riding the bus (Grant 2019). As Berge and Muilenburg (2013) argue, the learners themselves are *mobile*. Learners have the flexibility of using portable devices to reach out to the world and seek information of their choice when needed, in other words, "just-in-time, just enough, and just-for-me" (Traxler 2005, p. 14). While this is somehow true for all cases of mobile learning, recent technologies specifically made for mobile microlearning offer potential for supporting the learning process in new ways. These features bring new challenges to both learning technology and instructional methods. The main challenge is how to design significant learning content and assignment on small screens of mobile devices while still providing meaningful learning. Different guidelines for designing mobile microcourses and micro-contents have been proposed in literature (Jahnke et al. 2019). However, whether a specific design of mobile microlearning can support the learning process has not been sufficiently studied.

Mobile microlearning is a mix of two designs of digital technology and instructional method. There is a codependency between them in that the design of technology and its affordances affect the instructional method and vice versa. As Jonassen et al. (1994) address, debating the separation of media and methods—as Clark (1994) and Kozma (1994) do—is the wrong debate. Rather, learning takes place as "situated learning" (Brown et al. 1989), meaning that learning is situated and constructed through the learner's activities embedded into a certain context in which new knowledge or skills will be used. MML is part of the learner's context or environment; the learner does not learn *from* it but *with* it when constructing new knowledge. Kozma (2000) acknowledged later that *learning experiences* exist in a complex mess of media and instructional methods. He writes, "Understanding the relationship between *media, design, and learning* should be the unique contribution of our field to knowledge in education." (p. 12, emphasis added). It is critical that researchers embed themselves into the learners' contexts and deeply understand the relationship among the media (digital technology) they use, the learning materials they engage with, and their real learning situations. They will then be able to develop a better learning solution. Hence, Kozma advises the use of formative research, such as design-based or educational design research. This viewpoint implies a shift from asking the question of "what works" in general to more socially responsible questions, in particular "What is the problem, how can we solve it, and what new knowledge can be derived from the solution?" (Reeves and Lin 2020, p. 8).

The mobile microlearning approach is especially interesting for learners outside traditional office environments who often use smartphones, for example, journalists working in the field to cover breaking news or employees at work who need quick solutions to problems (Wenger et al. 2014). As Wenger et al. (2014) shows, journalists should know "how to gather news with mobile devices, use them to interact with the social media audience, and how to format content appropriately for the medium" (Wenger et al. 2014, p. 138). Whether outside or in offices, they should know how to document information or edit a real-time video quickly so as to effectively present breaking news. In journalism, the *5 Cs of Writing News for Mobile Audiences* refers to specific guidelines for writing news for a social media or digital news audience: Be Conversational, Be Considerate, Be Concise, Be

Contextual, and Be Chunky (Baehr et al. 2010; Montgomery 2007). But there have been few education research studies focusing on how and in what ways a mobile microlearning approach supports journalists' professional development in digital skills (Umair 2016).

Hence, this study aims to investigate how and in what ways a mobile microcourse can help journalists achieve certain learning objectives (e.g., understanding and applying the 5 Cs) and examine how the mobile microlearning course supports the learning process and affects the learner experience and learning efficacy including effectiveness, efficiency, and appeal (Honebein and Honebein 2015; Reigeluth and Carr-Chellman 2009).

Literature review

Literature shows that mobile microlearning approaches have increased over the past few years (Emerson and Berge 2018; Nikou and Economides 2018b). It has become a new teaching approach across disciplines, such as nursing education (Hui 2014), medical training and health professions (Simons et al. 2015), language training (Fang 2018), engineering (Zheng et al. 2019), science education (Brom et al. 2015), and programming skills (Skalka and Drlík 2018).

MML can improve learner motivation, engagement, and performance (Dingler et al. 2017; Jing-Wen 2016; Kovacs 2015; Liao 2015; Sirwan Mohammed et al. 2018; Zheng 2015). For example, the study by Nikou and Economides (2018b) reveals that microcontents given as homework activities in science learning can improve high school students' motivation and performance. In addition, MML has become a promising learning approach that personalize learning materials on small screens and portable devices to the learners' needs (Cairnes 2017). New teaching strategies, such as interactive microcontent, go beyond short videos by incorporating elements such as gamified learning activities (Aitchanov et al. 2018; Dai et al. 2018; Göschlberger and Bruck 2017). Because of limited time for learning in the workplace, mobile microlearning may have the advantage of flexibly and quickly conveying factual knowledge related to job skills (Decker et al. 2017).

However, issues with mobile microlearning include a lack of awareness and understanding about what microlearning can and cannot do (Baek and Touati 2017; Clark et al. 2018). Working on smartphones, learners can become distracted from their learning when writing text messages instead of completing lessons (Andoniou 2017). Additional research points to issues of accessibility, such as the need to provide offline versions of lessons for those with limited internet and to control bias related to gender, race, and age (Bursztyn et al. 2017). Also, streaming videos can result in relatively high costs, making it unaffordable for users. Another set of studies points to the problems of designing for small screens, including having too much information to fit and making it hard for users to search learning materials (Kabir and Kadage 2017).

Current research is in agreement that designing a mobile microcourse is challenging. One of the major elements that researchers have studied in past years is gamification (using gamified activities) (Ahmad 2018) and its connection to mobile microassessment, that is, using formative gamified activities to assess learners' knowledge (Nikou and Economides 2018b). Furthermore, several studies point to specific principles for designing microlearning as outlined below (Cates et al. 2017; Nickerson et al. 2017; Park and Kim 2018; Sun et al. 2017; Yang et al. 2018).

- It creates content that fits the small screens of mobile devices.
- It addresses learners when they need the knowledge at that moment in time. For example, journalists in the field reporting breaking news need immediate knowledge on how to write for social media audiences. That means the lessons are short, no longer than 5 min.
- It follows a specific instructional flow: (a) an aha moment that helps the learner understand the importance of the topic, (b) interactive content, (c) short exercises, and (d) instant automated feedback.
- It requires the learner to interact with the content using practical gamified activities (e.g., drag and drop, fill in the blank, and rearrange words in the correct order).

As Jahnke et al. (2019) note, most of the underlying design principles behind mobile microlearning platforms are behavioristic, focusing on the learners' click behavior. However, whether a specific design of mobile microlearning effectively supports learning—and how the learners experience the learning process *with* mobile microlearning—has not been sufficiently studied. Therefore, we investigated how a mobile microlearning course with Jahnke et al.'s (2019) four instructional flow design principles of MML affect learners' knowledge gain, skills, and confidence. The four principles are demonstrated in detail with examples in the next section ("Design of mobile microlearning"). We chose learners in the field of journalism who were learning to write news for mobile audiences, which is a critical skill for journalists in their profession.

The **research questions** (RQs) of this study are as follows.

RQ1: To what extent does a specific design of a mobile microcourse increase learners' knowledge and skills?

RQ2: To what extent does a specific design of a mobile microcourse affect the confidence of the learners in their professional skills to write news headlines and news stories for mobile audiences?

RQ3: What is the learner experience when interacting with the mobile microcourse?

To study these questions, this study applied a formative research approach (McKenney and Reeves 2018) that is, generally speaking, an iterative model of designing, testing (or evaluating), and researching. "The data are analyzed for ways to improve the course, and generalizations are hypothesized for improving the theory" (Reigeluth and Frick 1999, p. 5). This study adopted the framework of Honebein and Honebein (2015) who differentiate the three learning outcome values of instructional methods as effectiveness, efficiency, and appeal. According to them, "effectiveness is a measure of student achievement, efficiency is a measure of student time and/or cost, and appeal is a measure of continued student participation, which in other words means did students like the instruction" (p. 939). Aligned with this framework, the study examined learner experiences with a mobile microlearning course.

Design of mobile microlearning (MML)

This study investigated a mobile microlearning course, *The 5 Cs of Writing News for Mobile Audiences*, that applied the four specific design principles (Jahnke et al. 2019). The *5 Cs* design process and the microlessons' design are described in the following sections.

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Overall design and development procedure

The mobile microcourse was designed for the small screens of mobile devices, namely smartphones. An iterative process of course design, development, and modification was conducted in a three-stage evaluation. In the first stage, an expert journalist of the research team created the first draft of the microlessons on the selected mobile micro-learning platform, EdApp, based on literature review and mobile microlearning design principles as proposed by Jahnke et al. (2019). EdApp offers many templates with informational and interactive slides adaptable to different subjects.

In the second stage, two researchers in the study and two external experts conducted the first review of the draft of the microlessons and provided recommendations. The main adjustments in the first stage focused on wording, learning content, presentation formats, and interactive functionalities in the mobile application.

In the third evaluation stage, a pilot test was conducted for gathering feedback from real users to assess whether the revised microcourse content was understandable and reliable. Five volunteers, who were students enrolled in a digital media design course, were recruited as the pilot testers. They were asked to go through the entire mobile microcourse, as well as the pre- and postsurveys and pre- and posttests. The testers' recommendations and feedback were applied to modify and improve the course. The main revisions in the third stage focused on revising content length, modifying the difficulty levels of exercises and activities, and adjusting overall instructional flow. Consequently, the final version of the mobile microlearning course for this study was confirmed and called, *The 5 Cs of Writing News for Mobile Audiences*. The course content included five topics (*5Cs*): (a) be conversational, (b) be considerate, (c) be concise, (d) be contextual, and (d) be chunky. The course targets journalism students and professional journalists who want to learn how to write effective news headlines and news stories for mobile audiences.

Overview of the microlessons, design, content, and sequence of activities

The five microlessons addressed the learning goal of how to effectively write journalistic news for mobile audiences. In response to the growing consumption of mobile news on smartphones, schools of journalism have recently added instruction in writing for this audience. Senior journalists, however, may not have received this training. In detail, the mobile microcourse's learning goal is that after course completion, learners will be able to apply the 5 Cs, meaning they will be able to write a news headline or a news story for mobile audiences by using the 5 Cs. Each of the five lessons had the same four-step instructional flow, which was an adapted version of Gagne's et al. (1992) nine events of instruction. Because lessons in mobile microlearning should be short (no more than 5 min), literature suggests that the design of MML should be based on the following four learner activities in this sequence (Jahnke et al. 2019).

(1) Learners understand the relevance of the topic (an aha moment). (Gagne's #1: Gain attention of the students).
(2) They read and engage with interactive content. (Gagne's #4: Present the content).
(3) They apply the learned content in short exercises. (Gagne's #6: Elicit performance, meaning students practice).

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(4) They receive immediate automated feedback on performance. (Gagne's #7: Provide feedback and #8: Assess performance).

Gagne's event #2 (inform students of the learning objectives), is inherent in the introduction to the microcourse, before the learner actually starts the course. Gagne's #3 (stimulate recall of prior learning), #5 (provide learning guidance), and #9 (enhance retention and job transfer) are all incorporated through the human–computer interaction design of the MML digital application with gamified activities, drag and drop exercises, short questions, filling in missing words, and so forth.

Based on these four activities for learners, the following sections provide specific examples and screenshots of the microcourse studied.

(1) Students understand the relevance of the topic (an aha moment).

Before students started the microcourse, they read a short paragraph that offered a brief introduction to the course and to each of the 5 Cs. Then, each of the five lessons started with an aha moment to help learners understand the relevance of the topic.

For example, in the lesson *Be Considerate* (see Fig. 1), learners were asked to put themselves in the shoes of mobile readers. In addition to building empathy with the mobile audience, the sequence was designed to lead to an aha moment for learners about how their audience consumes news on a mobile phone. In applying the design principle of a sequenced and engaging instructional flow, the aha moment was followed by the learning objective (Jahnke et al. 2019).

(2) Reading and engaging with interactive content.

After understanding the topic's relevance, students read or engaged with interactive content. The microcourse did not just display learning materials, but learners interacted with the learning materials in multiple ways. It differed from the one-way traditional textbook or e-book, in which learners can only read materials.
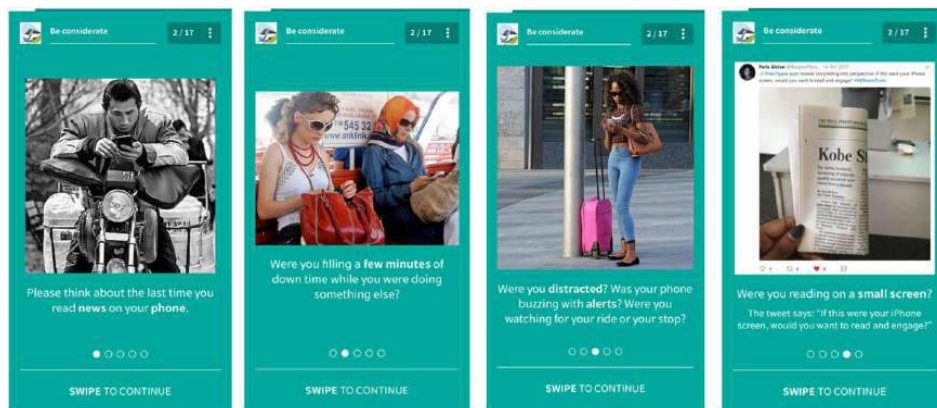

Fig. 1 Screenshots from the microlesson, *Be Considerate*. It illustrates designing for an aha moment, helping learners understand the relevance of the topic (*Learner swipes to continue.*)

Fig. 2 Screenshots from the *Be Concise* microlesson show a swipe-through-words exercise to remove words and improve the sentence. The left figure is before swiping and the right figure is after
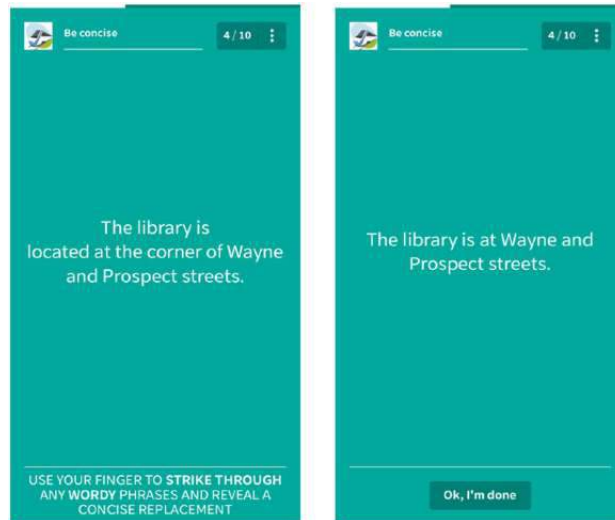
For example, in the *Be Concise* microlesson (see Fig. 2), learners used their fingers to swipe through and eliminate words to improve the sentence by making it more concise. This microlesson applied the design principle of interactive microcontent for closing practical skill gaps (Jahnke et al. 2019). A mobile microlearning lesson has interactive elements in which learners can practice and apply what they have learned (e.g., drag and drop, quizzes, and simulations).
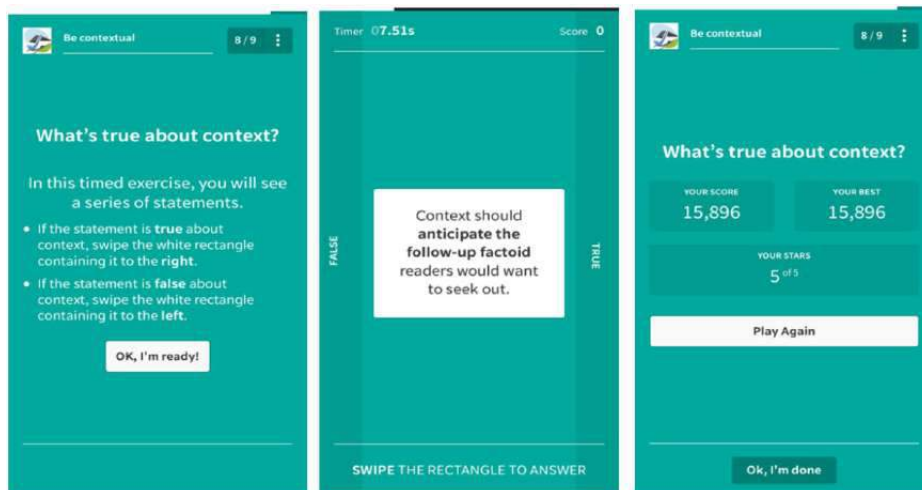
Fig. 3 Screenshots from the *Be Contextual* microlesson show a true or false gamified quiz

(3)   Applying learned content in short exercises (gamified activities).

After students engaged and hopefully learned the content, short exercises were offered, and many of them were gamified activities.

An example of a short exercise is shown in Fig. 3. It is from the *Be Contextual* microlesson. Learners had 10 s to earn up to five stars by swiping true statements to the right and false statements to the left. The final slide in Fig. 3 summarizes the learner's performance on this gamified quiz and offers a chance to play again. The chosen platform provides a way for learners to trade in their stars for prizes if the administrator decides to activate it. The microlesson applied the design principle of short exercises (Jahnke et al. 2019). The purpose was to engage users by requiring action when using the content.

(4)   Receiving instant automated feedback on performance.

The final step of the microlesson included feedback for students. They received immediate automated feedback on their performance from the applied exercises just described. An example is shown in Fig. 4. By tapping the arrows, the learner chose the correct answer from multiple options. Immediate feedback enabled users to correct performance on the spot and provided direction on what they need to work on.

The learning content, materials, activities, and exercises in the 5 Cs microcourse were designed in a bite-size manner; each lesson takes about 5 min. The flow of the 5 Cs mobile microcourse is shown in the Appendix Table 9.

Methods

This formative study of educational design research (McKenney and Reeves 2018) was conducted from September to November 2018 with 35 users. Participants downloaded the application (app) to their personal mobile phones. The original plan included 8 days to complete the course, but some participants took longer (see "Results" section). Participants could use the app whenever they had 5 min to complete a microlesson, e.g., while sitting on a bus or waiting in a line to get coffee.

Fig. 4 Screenshots of the *Be Conversational* microlesson show the instant feedback that learners receive after answering a question
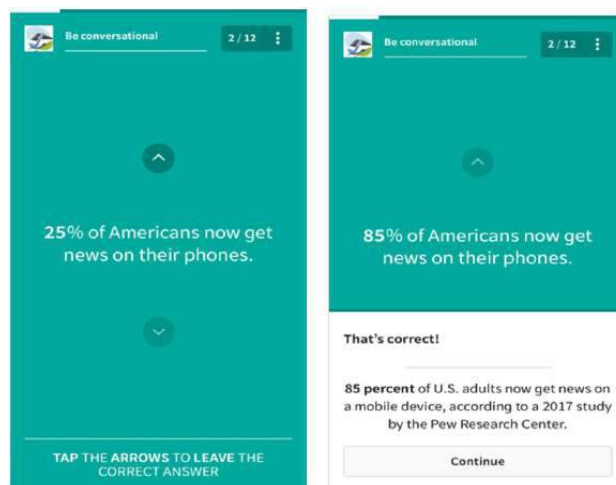
The actual study process consisted of three steps. (Details are shown in the Appendix Table 9.) First, participants logged in and completed a precourse survey and a pretest. The precourse survey contained eight questions about basic demographic information (e.g., gender), position in the professional field, years of work experience, and perceptions regarding personal skills and existing knowledge about writing news for mobile audiences. The pretest measured the initial knowledge of learners before the microcourse. Second, participants completed the microlessons step by step, then answered a survey regarding their learning perceptions. In each of the five postlesson surveys, five questions were included regarding participant experience, perception, and concerns. Third, after completing the course, participants took a postcourse survey and a posttest. The postcourse questionnaire included 11 questions regarding participant skills, existing knowledge, and perceptions focused on the topic. For example, "In a few words, tell us up to three things you should remember when writing news for mobile audiences" (Q1). "I learned new things about how to write for mobile audiences" (Q2). "I am confident in my skills to write news stories for mobile audiences" (Q6). The posttest measured the gained knowledge of learners after completing the course.

Our hypothesis for the pretests and posttests was that the knowledge level would be relatively higher after the course. The pre- and posttests measured individual participants' learning growth (La Barge 2007). Both the pre- and posttests had the same ten multiple-choice questions. The correct answers were created by an expert journalist. Questions #1 to #9 asked the learners to select a best headline. For each of those nine questions, the correct answer was the headline that led to at least a doubling in readers of a story on a major metropolitan newspaper's website. One of the incorrect choices was the headline it replaced in an effort to improve reader traffic, and the third choice was a distractor. Question #10, "Which technique can be applied to chunk news stories?" was a multiple-choice question.

All surveys, online questions, and tests were included in the mobile application delivering the mobile microlearning course.

Data analysis

Qualitative data, such as responses to open-ended questions in the surveys, were analyzed with a thematic analysis approach (Boyatzis 1998). Quantitative data included the total course-completion time, the average completion time of each microlesson, pre- and postcourse surveys, and pre- and posttests. Data were analyzed with three statistical methods: a paired sample *t*-test, a one-way ANOVA, and a Pearson correlation coefficient comparison (Benesty et al. 2009; Park 2009). Quantitative data also included pre- and posttest scores, as well as Likert-scale responses to certain questions in the surveys.

For the pre- and posttests, the study used the same ten questions. The test scores were analyzed in two ways: a traditional scoring method of correct/incorrect answers (Shadiev et al. 2018) and a qualifier scoring method (La Barge 2007). For the traditional scoring method, learners who correctly answered one question could obtain 10 points, so that the maximum score for the test was 100 points. For the qualifier method, participants were given two qualifier options after each test question: "I knew the answer" and "I was guessing." Examples are in Fig. 5. This method gave additional information on whether the answer was a lucky guess or whether learners were applying knowledge. Questions in which the learners indicated that they were guessing were counted as incorrect in the qualifier method for determining the number of correct responses (La Barge 2007).
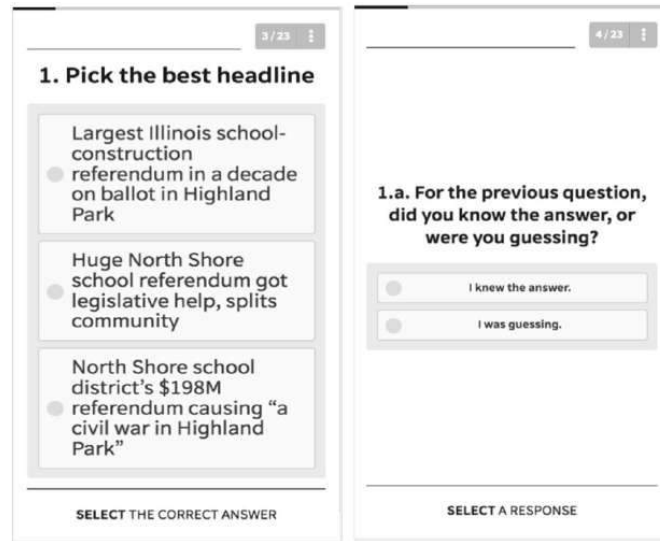
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Fig. 5 Screenshots show the first question in the microcourse's pre- and posttests and the follow-up question

The study investigated the users' learning growth (i.e., gained score) by the comparison of pre- and posttest scores. Adopted from the Missouri Department of Education's Setting Growth Targets for Student Learning Criteria (2015), five-tiered growth targets were applied as measurement criteria for effective learning.

Tier One (Beginning): Pretest scores ranged from 0 to 40 out of 100 points. Learners in Tier One should reach a minimum expected target score of 60 points on the posttest to indicate effective learning.

Tier Two (Far but Likely): Pretest scores ranged from 41 to 60 points. Learners in Tier Two should reach a minimum expected target score of 70 points on the posttest to indicate effective learning.

Tier Three (Close to Proficient): Pretest scores ranged from 61 to 75 points. Learners in Tier Three should reach a minimum expected target score of 80 on the posttest to indicate effective learning.

Tier Four (Proficient): Pretest scores ranged from 76 to 85 points. Learners in Tier Four should reach a minimum expected target score of 90 on the posttest to indicate effective learning.

Tier Five (Proficient and Expert): Pretest scores ranged from 86 to 100 points. Learners in Tier Five should reach a minimum expected target score of 95 on the posttest to indicate effective learning.

We applied the three methods (traditional-score analysis, qualifier-score analysis, and learning-growth target score analysis) and have defined effective learning as follows. First, at least 80% of the learners obtain higher scores in the posttest after completing the mobile microcourse. Second, the average score (*mean score*) of learners in the posttest should be higher than in the pretest. Third, at least 65% of learners achieve the growth target postscore for their tier-level group (Fiore et al. 2017; PowerSchool 2016).

153

Participant recruitment

Thirty-five participants were recruited for the study, including 28 women and 7 men. The valid sample sizes were estimated according to Eng (2003), which offers a sample size calculation method for comparative research studies (applying Eq. (1), in: Eng 2003, p. 310). According to the proposed equation, the sample size calculated for the study was 31.4. In the calculation, the estimated standard deviation (*SD*) and the estimated minimum expected difference (*D*) between the pre- and posttests' mean scores was 10 points; a single unit score for each question item was 10 points. The selected significance criterion was 1.96 (.05), and the statistical power was .842 (.80) (Eng 2003, Table 1 and Table 2, p. 311). Accordingly, the study met the minimum expected sample size ($n = 31.4$) by recruiting 35 participants.

Participants had to be journalism students, journalism educators, or journalists to qualify for the study. At the time of the study, 14 participants reported up to 5 years of work experience in journalism; five had worked 6–10 years; nine had worked 11–19 years, and seven had worked 20 years or more.

The sampling process was conducted with a journalism fellow. A list of 98 potential users was given to the research team. Those on the list were clustered into four groups based on their years of experience in journalism, including 37 individuals with 0–5 years of experience, 15 individuals with 6–10 years of experience, 23 individuals with 11–19 years of experience, and 23 individuals with 20 or more years of experience. The research team randomly selected 35 users. As soon as one of the participants dropped out, the next user on the list was requested, and so on, until 35 users completed the microcourse, surveys, and tests. Participants were asked to use their personal smartphones. As an incentive, each participant who went through the entire course and completed the tests and online questionnaires received a $50 gift card.

Results

In this section, study results are described and organized as to the design of mobile microlearning course's effectiveness, efficiency, and appeal.

Efficiency

Time to complete the mobile microcourse and each lesson

The time to complete the course was expected to be 8 days or less. The actual time that participants took to complete the course varied with 13 participants taking 1–3 days, four participants taking 4–5 days, five participants taking 6–8 days, and 13 participants taking more than 8 days. The average time to complete the course for all 35 participants was 8.8 days.

Learning duration of each lesson

The participants' average time spent on each lesson ranged from 4.4 to 4.9 min, with an average of 4.7 min. The average time spent on each lesson is listed below from the longest to the shortest time.

- *Be Conversational*: 4.9 min
- *Be Considerate*: 4.9 min
- *Be Chunky*: 4.7 min
- *Be Contextual*: 4.5 min
- *Be Concise*: 4.4 min

In response to the question of whether the lesson (a) too long (coded point 3), (b) about right (coded point 2), or (c) too short (coded point 1), the mean score is 1.86 ($SD = .36$), and most of the participants (86%) said that each microlesson's length is about right.

Effectiveness

Participants' perception of difficulty levels about the course

Participants were asked about the difficulty level of each lesson by responding to whether the lesson was (a) too hard (coded point 3), (b) about right (coded point 2), or (c) too easy (coded point 1). The mean score was 2.06 ($SD = .34$), and most of the participants (88%) said the difficulty level in each lesson was about right.

Participants' comfort level in using mobile technology

Participants' comfort level in using mobile technology was assessed based on their response to Q7 in the precourse survey: "I am comfortable using mobile technology." Their average comfort level in using mobile devices was 4.31 points (on a 5-point Likert scale, 5 = strongly agree). About half of the participants (49%) strongly agreed, and 40% agreed that they felt comfortable using mobile devices. Eight percent expressed a neutral opinion and three percent strongly disagreed that using mobile technology was comfortable for them. Using the one-way ANOVA analysis, results show significant differences ($F (3, 31) = 2.968$, $p = .000$) among the four groups in their comfort level in using mobile technology. The quantitative data analysis was specified on a 95% confidence level for all statistical tests in the study (see Table 1).

Moreover, Table 2 shows the Fisher's Least Significant Difference Post Hoc test (a pairwise-comparison to compare each group's difference with the other, one by one). The groups were A (0–5 years of experience), B (6–10 years), C (11–19 years) and D (20 or more years). Group C ($M = 3.88$, $SD = 1.36$) was significantly different from Group A ($M = 4.47$, $SD = .51$, $p = .009$) as well as Group B ($M = 4.04$, $SD = .55$, $p = .045$). It means that participants in Group C (with job experience of 11–19 years) expressed less comfort level in using mobile technologies than participants with < 10 years of job experience. When comparing Group C and Group D ($M = 4.29$, $SD = .76$,

Table 1 One-way analysis of variance (ANOVA) results on participants' comfort level in using mobile technology

Predictor	Sum of squares	df	Mean square	F	p values
Group	5.70	3	1.90	2.969	.000**
Comfort level	19.84	31	.640		
Total	677.00	34			

Statistically significant differences: *$p < .05$. **$p < .001$

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Table 2 One-way analysis of variance (ANOVA) post hoc comparisons on four participant groups' comfort level in using mobile technology

Group	n	M	SD	Fisher's LSD post hoc test (p value)		
				A (0–5)	B (6–10)	C (11–19)
A (0–5)	14	4.47	.51			
B (6–10)	5	4.40	.55	.919		
C (11–19)	9	3.88	1.36	.009*	.045*	
D (20+)	7	4.29	.76	.342	.507	.135

In Fisher's least significant difference (LSD) post hoc test, the mean (M) differences between groups are significant when the *p value* < .05, as marked by "*"

$p = .135$), there was no statistical significance between the two groups. While comparing Group D with Group A ($M = 4.47$, $SD = .51$, $p = .342$) and Group B ($M = 4.04$, $SD = .55$, $p = .507$), results showed no significant differences between their comfort levels in using mobile technologies.

Participants' confidence in writing news headlines and stories for mobile audiences

Participants were asked about their confidence in writing news headlines for mobile audiences in Q6 of the precourse survey and Q5 of the postcourse survey. They rated the statement, "I am confident in my skills to write news headlines for mobile audiences," on a 5-point Likert scale (5 = strongly agree). Using the statistical analysis of a paired sample *t*-test, results indicate that participants' confidence level in writing news headlines was significantly higher after they completed the course ($M = 3.86$, $SD = .81$) than before the course ($M = 3.06$, $SD = .97$), ($t(34) = -5.253$, $p = .000$) (see Table 3).

Participants were also asked about their confidence in writing news stories for mobile audiences in Q8 of the precourse survey and Q6 of the postcourse survey by rating their agreement with the statement, "I am confident in my skills to write news stories for mobile audiences," on a 5-point Likert scale (5 = strongly agree). Using the statistical analysis of a paired sample *t*-test, results indicate that participants' confidence level in writing news stories was significantly higher after the course ($M = 4.23$, $SD = .81$) than before the course ($M = 3.60$, $SD = 1.09$), ($t(34) = -3.421$, $p = .002$) (see Table 3).

Table 3 Participants' confidence level in writing news headlines and stories for mobile audiences

Test scores	n	M	SD	t-test	df	p values
Writing news headline						
Pretest	35	3.08	.97	− 5.253	34	.000
Posttest	35	3.86	.81			
Writing news stories						
Pretest	35	3.60	1.09	− 3.421	34	.002
Posttest	35	4.23	.81			

M the mean score of confidence level, *SD* standard deviation

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Participants' confidence in writing mobile news after each of the five microlessons

Participants were asked about their confidence in writing mobile news after completing each microlesson. Q1 in each postlesson survey was, "I feel more confident in writing mobile news after completing this lesson" (on a 5-point Likert scale, 5=strongly agree). Figure 6 shows that the majority of participants agreed that they had more confidence in writing after completing each lesson.

In these five lessons, since the lesson, *Be Contextual*, had the lowest agreement at 63% (20% strongly and agree 43% agree), we looked into the 37% of the responses that were rated as neutral or disagree. These 37% participants (P) said in the open-ended survey that the *Be Contextual* lesson is too short, and it would be better to include more examples and practice for this topic. For example, P5 mentioned, "This lesson could have been a little longer." P15 mentioned, "[It] need[s] more examples," and P25 said, "[It] could have used more practicing." Accordingly, compared to the other microlessons, the lower confidence level in writing mobile news contextually (63%) appears to indicate the lesson is too short and needs more examples and practice in order for learners to master the skills of being contextual and, consequently, have more confidence in applying them.

Participants' knowledge of how to write news for mobile audiences

Q6 of the precourse survey and Q1 of the postcourse survey asked, "In a few words, tell us up to three things you should remember when writing news for mobile audiences." The purpose of this question was to assess whether the learners' cognitive knowledge of how
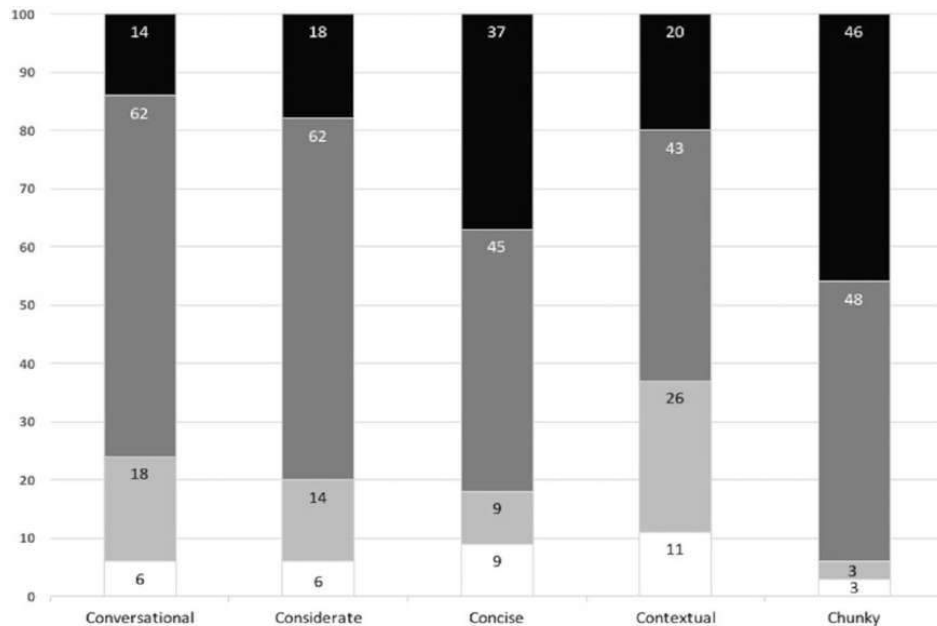

Fig. 6 Participants' confidence (*n*=35) after each lesson, as rated on a 5-point Likert scale (5=strongly agree to 1=strongly disagree), where the black bar=strongly agree, the dark gray bar=agree, the light gray bar=neutral, and the white bar=disagree and strongly disagree

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Table 4 Clustered themes of participants' answers to an open-ended question about writing news for mobile audiences

Precourse answers Clustered theme (CT = 14)	f	Postcourse answers Clustered theme (CT = 2)	f
CT1: Keep it brief	18	CT1: Be concise	31
CT2: Be concise	11	Be conversational	26
CT3: Pay attention to words/spelling/URLS	8	Be contextual	16
CT4: Keep it simple	7	Be chunky	11
CT5: Readers read in short moments	6	Be considerate	11
CT6: Headlines	6	Be brief/short	2
CT7: Be accurate	6	CT2: Others: Consider audiences' needs, break	1
CT8: Break it up	4	up paragraphs, use bullet points, be detailed,	
CT9: Use graphics	4	prompt a reaction, make stories readable, use	
CT10: Be engaging	3	subheads)	
CT11: Be conversational	3		
CT12: Write for small screens	2		
CT13: Be considerate	1		
CT14: Other concepts mentioned only once (e.g., describe the story, be interactive, be brief, be compelling, offer value)	11		

f = frequency of how often each of the 35 participants mentioned a theme (multiple answers were allowed)

to write news for mobile audiences changed after the 5 Cs course. Table 4 shows that the 35 learners' cognitive knowledge was impacted by the microlessons covering the 5 Cs: Be Conversational, Be Contextual, Be Concise, Be Considerate, and Be Chunky. Before the course, participants' responses could be clustered into 14 themes (see Table 4). After the course, participants' responses were clustered into two themes. The first theme focused on the 5 Cs of writing conversationally, considerately, concisely, contextually, and in a chunky way (see Table 4). After the course, 32 of the 35 participants (91.4%) were able to list the concepts and relevant knowledge about the 5 Cs and 3 of the 35 participants (8.6%) provided other comments in addition to comments related to the 5 Cs.

Pretest and posttest results

The pretest and posttest results were analyzed by two methods including the traditional scoring method and the qualifier scoring method (see the "Methods" section).

Figure 7 shows the traditional-analysis test scores before (gray line) and after (black line) the course. Results indicate that 80%, 28 out of 35 participants (Ps), obtained higher test scores after completing the course, as shown by the black line in Fig. 7. Three of 35 participants (P 29, P 30, P 31) received the same scores before and after the course as shown by the black line and the gray line overlapping in numbers 29, 30, 31 on the horizontal axis in Fig. 7. Four of 35 participants got lower scores after completing the lessons, resulting in the black line (posttest course) being lower than the gray line (pretest score) for P32–P35.

The posttest scores (M = 73.14, SD = 13.88) are statistically significantly higher than the pretest scores (M = 56.00, SD = 15.18) according to the paired-sample t-test, $t(34)$ = − 5.823, p = .000. The microcourse had a statistically significant effect on
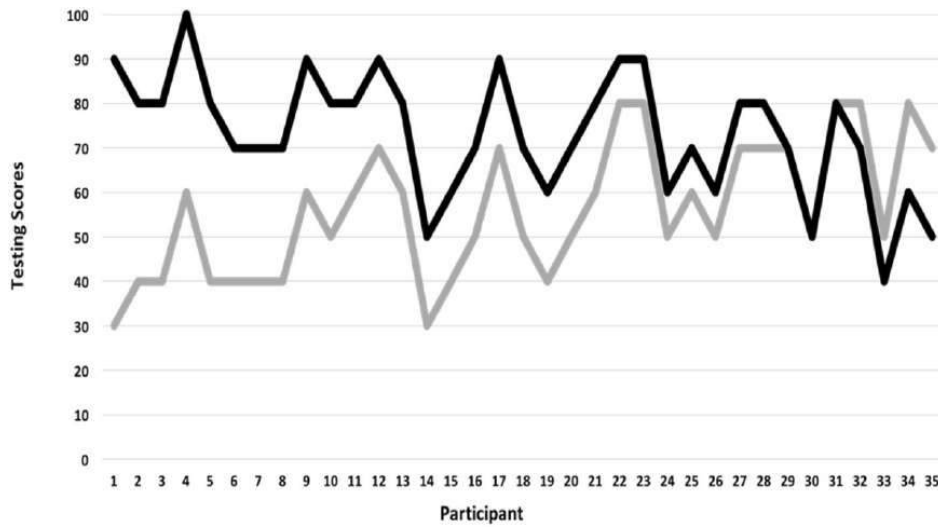
Fig. 7 Traditional analysis test scores of each participant in the pre- and posttest ($n=35$) gray line = pretest, black line = posttest

participant performance; the average score increased 17 points in the posttest. After the course, participants had gained knowledge about how to apply the 5 Cs in news writing. However, there were individual differences. For example, P1 gained 60 points while P27 gained only 10 points.

Furthermore, results of the pre- and postcourse *guessing rate* show that the guessing rates of 86% (30 of 35 individuals) of participants decreased after the course. In Fig. 8, the gray line indicates the precourse guessing rate, and the black line represents the
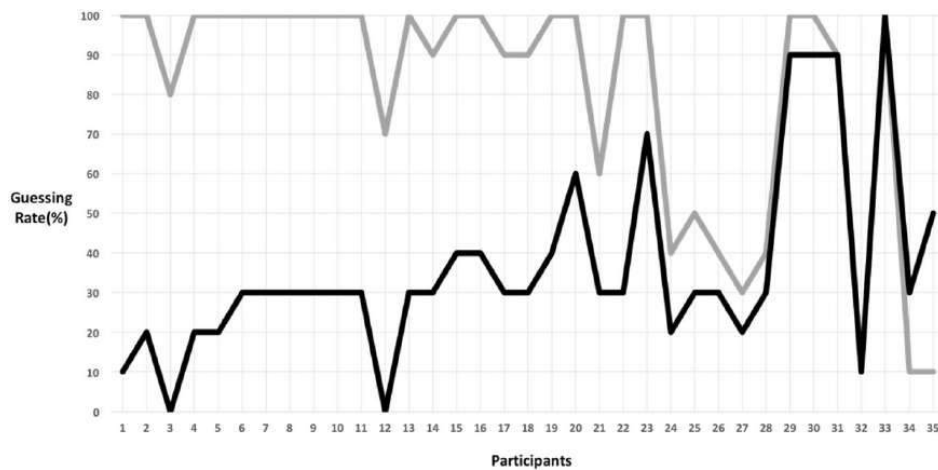

Fig. 8 Participants' guessing rates (%) on the same test given before and after the course (n=35); gray = before, black = after. A guessing rate of 100% means the participant guessed on 100% of the questions (rather than knowing the correct answer) and 0% means guessing on none of the questions

postcourse guessing rate. Three people had the same guessing rate before and after. Two people had higher guessing rates after completing the course.

A Pearson correlation coefficient was computed to assess the relationship between the test performance and guessing/knowing ratio (Benesty et al. 2009). There was no significant correlation between the learners' pretest performance and guessing/knowing rates (guessing rate: $r=.16$, $n=35$, $p=.33$; knowing rate: $r=-.03$, $n=35$, $p=.86$). The pretest guessing/knowing rates are scattered among the 35 learners. However, in the posttest, there was a significant correlation between the learners' posttest performance and guessing/knowing rates (guessing rate: $r=-.34$, $n=35$, $p=.04$; knowing rate: $r=.34$, $n=35$,

Table 5 The number of learners' pretest and posttest raw score versus guessing rate (N=35)

Pretest	Guessing rate (%)											
Raw score	0	10	20	30	40	50	60	70	80	90	**100**	Total (n)
0												
10												
20												
30											2	2
40				1	1			1		1	4	**8**
50	1				1	1	1	1		2	1	**8**
60					1						6	6
70	1									1	4	6
80	1										4	5
90												
100												
Total (n)	3	0	0	1	3	1	1	1	1	4	**20**	35

Posttest	Guessing rate (%)											
Raw score	0	10	20	**30**	40	50	60	70	80	90	100	Total (n)
0												
10												
20												
30												
40						1						1
50					1					1	1	3
60	1		1	1	1		1					5
70				8	1							9
80	1	1	2	3				1		2		**10**
90		1	2	3								6
100				1								1
Total (n)	2	2	5	**16**	3	1	1	1	0	3	1	35

The bold values in the Total (n) section show the most frequent counts in the distribution of the 35 participants

n the number of learners

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Table 6 The number of learners' pretest and posttest raw score versus knowing rate (N = 35)

Pretest Raw score	Knowing rate (%)											Total (n)
	0	10	20	30	40	50	60	70	80	90	100	
0												
10												
20												
30	2											2
40	4	1	1				1	1				**8**
50	1	2		1	1	1	1			1		**8**
60	5						1					6
70	4	1								1		6
80	4									1		5
90												
100												
Total (n)	**20**	4	1	1	1	1	3	1	0	3	0	35

Posttest Raw score	Knowing rate (%)											Total (n)
	0	10	20	30	40	50	60	**70**	80	90	100	
0												
10												
20												
30												
40						1						1
50	1	1					1					3
60					1		1	1	1		1	5
70							1	8				9
80		2		1				3	2	1	1	**10**
90								3	2	1		6
100								1				1
Total (n)	1	3	0	1	1	1	3	**16**	5	2	2	35

The bold values in the Total (n) section show the most frequent counts in the distribution of the 35 participants

n the number of learners

$p = .04$). After the course, the learners' guessing rate significantly decreased, and the knowing rate significantly increased. Tables 5 and 6 summarize the results.

Applying the Tier One to Tier Five learning growth criteria (introduced in the "Data analysis" section), the results of pre- and posttest scores analysis are shown in Table 7. In Tier One, 100% of the learners ($n = 10$ in pretest; $n = 10$ in posttest) achieved the minimum target score of 60 points on their posttest. In Tier Two, 71.42% of the learners ($n = 14$ in pretest; $n = 10$ in posttest) achieved the minimum target score of 70 points on their posttest. In Tier Three, 66.66% of the learners ($n = 6$ in pretest; $n = 4$ in posttest) achieved the minimum target score of 80 points on their posttest. In Tier Four, 40% of the learners ($n = 5$ in pretest; $n = 2$ in posttest) achieved the minimum target score of 90 points on their posttest.

Table 7 Participants' learning growth between the pretests and posttests (N = 35)

Tier	Pretest (*pretest scores*)	Posttest (*target scores*)	Learning growth (%)
Tier One (Beginning)	*n* = 10 (*0–40*)	*n* = 10 (*achieve min. 60*)	100.00
Tier Two (Far but likely)	*n* = 14 (*41–60*)	*n* = 10 (*achieve min. 70*) *n* = 2 (*higher but not 70*) *n* = 2 (*equal or lower score*)	71.42
Tier Three (Close to proficient)	*n* = 6 (*61–75*)	*n* = 4 (*achieve min. 80*) *n* = 2 (*equal or lower score*)	66.66
Tier Four (Proficient)	*n* = 5 (*76–85*)	*n* = 2 (*achieve min. 90*) *n* = 3 (*equal or lower score*)	40.00
Tier Five (Proficient and expert)	*n* = 0 (*86–100*)	n/a (*achieve min. 95*)	n/a
% (*Mean*)			69.52

The Tier 1–5 model was adopted from the Missouri Department of Education's Setting of Growth Targets for Student Learning Objectives: Methods and Considerations (2015). *n* means the number of participants. *min.* means minimum. (%) means the percentage of learners achieving the growth target points. n/a means no answer. There were no participants in Tier Five

Table 8 Precourse and postcourse testing scores: original-scoring and qualifier-scoring analysis results

Item (*I*)	Pretest			Posttest		
	% Correct	% Select I know	% Select I guess	% Correct	% Select I know	% Select I guess
I 1	71	24	76	83	72	28
I 2	69	29	71	89	81	19
I 3	63	23	77	83	86	14
I 4	11	50	50	29	70	30
I 5	31	18	82	63	82	18
I 6	63	14	86	51	78	22
I 7	86	20	80	86	80	20
I 8	94	21	79	86	87	13
I 9	23	38	62	57	90	10
I 10	40	29	71	94	97	3
% (*Mean*)	55	27	73	72	82	18

The same 10-item test was given both before and after the course

% = percentage of the 35 participants; I Know = "I knew the answer"; I Guess = "I was guessing the answer"

There was no participant in Tier Five (pretest, *n* = 0). Overall, 69.52% (*n* = 26) of learners achieved their learning-growth target scores and 30.48% (*n* = 9) of learners did not meet the minimum learning-growth target scores, including two learners whose scores increased but

did not achieve the minimum target growth, three learners who had equal scores in the pre- and posttests, and four learners who got lower scores in their posttest (see Table 7).

For the qualifier scoring results, Table 8 presents the percentage of the 35 participants who had the correct answers (using traditional scoring) on the pre- and posttests (see % *Correct* in Table 8) and the percentage of participants who obtained qualified correct answers (using qualifier scoring). A score was qualified when the participant got the correct answer and selected "I knew the answer" on the follow-up question (see % *Select I Know* in Table 8).

Under the traditional-scoring calculation, results indicate that, on average, 55% of participants correctly selected the right answer on the pretest and 72% of participants correctly selected the right answer on the posttest (see Table 8), an increase of 17 points.

In terms of the qualifier-scoring calculation, after each question, the qualifier analysis was based on whether the participant selected, "I knew the answer," or "I was guessing," on a follow-up question. If the participant answered correctly and also selected "I knew," the item was counted as a correct answer. If the participant answered correctly and also selected "I was guessing," the item was counted as an incorrect answer. Accordingly, results show the actual knowledge gained by participants in the course increased by 55 points, to 82% correct after the course from 27% before the course. Moreover, participants decreased their posttest guessing rate by 55 points to 18% as compared to their pretest guessing rate of 73%.

Lastly, there was no significant difference among the four groups (based on years of job experience) in their pretest or posttest guessing or knowing rates. The one-way ANOVA result for the four groups of the pretest guessing rate: $F(3, 31) = .476$, $p = .701 > .05$. The one-way ANOVA result for the four groups of the posttest: $F(3, 31) = 1.498$, $p = .237 > .05$.

Appeal

Participants' perception of convenience in fitting microlessons into their daily routine

Participants indicated how convenient it was to fit the microlessons into their daily routine on item #4 of the postcourse survey by rating their agreement with the statement, "Fitting the short lessons into my daily routine was convenient," on a 5-point Likert scale (5 = strongly agree). The average score was 4.29. Most participants (46% strongly agree and 40% agree) said that it was convenient to fit the short lessons into their daily routine. Among the four groups classified by work experience, all ranked similarly with averages between 4.00 and 4.43.

Participants' perceptions about the course

The postcourse survey collected data regarding effectiveness and recommendations. In item #2, participants rated their agreement as to whether they learned new things about how to write for mobile audiences on a 5-point Likert scale (5 = strongly agree). The average response was 4.31, with 49% strongly agreeing, 40% agreeing, 8% reporting a neutral opinion, and 3% strongly disagreeing. Using the same Likert scale, participants indicated whether exercises in the course were fun on item #3. The average score was 4.17, with 31% strongly agreeing, 54% agreeing, 15% reporting a neutral opinion, and no participants disagreeing or strongly disagreeing.

Recommendability

All 35 participants agreed that they would recommend the course. Many of the participants mentioned the course was interesting, short, helpful, convenient, and easy to use. Participants were asked to highlight one activity in the course they found helpful. In response, many of the participants (P) mentioned things such as "the interactive exercises such as writing their own headlines," (P 6), "visual quizzes" (P 28), "multiple choice questions in the review section," (P 13) and "real-life examples." (P27).

They also proposed having more practical examples and explanations to aid in understanding the course content. Some participants (P) shared positive comments. P15 said, "I liked the ability to strike the words from the sentences in the beginning. That was a pleasant interactive experience." P10 explained, "Seeing different examples of how two different headlines on the same story performed helped me understand how writing more conversational headlines can drive engagement and interest among readers."

Participants also shared concerns. P3 said, "I did not like the true/false game at the end. The statements were too long to read in the short amount of time and I found myself struggling." P33 stated, "The timed event made me, at times, worry more about the timer than what I was reviewing. Is it possible to make the allowed time longer?"

In addition, participants wanted to have clear navigation guidance before starting a game or an exercise and to receive personalized feedback on their responses. For example, P5 said, "How to choose an answer was sometimes confusing or not clear," referring to the swipe feature of some exercises. P17 concluded, "I thought the lesson worked well. However, when you submit your own headline, there's no way of knowing if it's a good headline or not."

Participants expressed concern about the timed true or false gamified quizzes and suggested extending the time so that they would be able to read the game instruction and answer the quiz. The true or false gamified quizzes that were too short were in the lessons of *Be Considerate, Be Contextual,* and *Be Chunky*. The time to answer each true or false question was 10 s. After each timed quiz, a replay button allowed participants to play the game again and again. The rationale of the timed games was to stimulate the engagement that occurs in playing games. However, the data show that the learners did not prefer the timed element.

Discussion

The study shows that the mobile microlearning course positively supports learning effectiveness, efficiency, and appeal. However, compared to the effect of efficiency and appeal, the design for learning effectiveness has room for improvement as the course was not equally effective for all learners.

Research question 1: To what extent does the mobile microcourse increase the learners' knowledge and skills?

Pre- and posttest results reveal the effectiveness of the microformat, with this course having significant positive effects on learning performance.

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The results show that this MML course supports the learning process. The data show that 80% ($n=28$) of learners significantly obtained higher scores in their posttest, achieving the effective learning hypothesis that at lest 80% of the learners obtain higher scores in the posttest. The learners' average posttest score was higher than in the pretest, achieving the goal of a statistically significant increase in posttest scores (see "Pretest and posttest results" section). In addition, in the qualifier-scoring analysis (guessing vs. knowing), learners' guessing rate in the posttest dropped by 55 points to 18%, compared to their pretest guessing rate of 73% (Table 8). This drop in the guessing rate indicates a decrease in learners' uncertainties (Burton and Miller 1999). In the relative learning-growth analysis, 69.5% ($n=26$) of learners achieved their minimum learning-growth target scores (Table 7).

However, 30.48% ($n=9$) of learners did not meet the minimum learning-growth target scores. Either their posttest scores were higher than their pretest scores but did not achieve the minimum target criteria, or their posttest scores were equal or lower than their pretest scores. These learners' performance indicates opportunities for improving the course.

Research question 2: To what extent does the mobile microcourse affect the confidence of the learners in their skills to write headlines and stories for mobile audiences?

Participants' confidence in writing a news headline and in writing a news story for mobile audiences have significantly increased after the MML course.

According to Bandura's (1977, 2010) social cognitive theory, a person's self-perceptions of confidence level in their capabilities to accomplish a specific performance can be defined as an individual's self-efficacy. The greater confidence people have that they can complete a task, the more self-efficacy they possess to achieve the task. In keeping with this concept, the study found that the mobile microcourse increased learners' confidence level, an indicator for self-efficacy. However, the increased confidence in writing news content for mobile audiences is related to the MML experience in its entirety. We have no data to indicate whether one element of the MML experience supported confidence more than other elements. Further studies are needed.

Research question 3: What is the learner experience when interacting with mobile microlessons?

All the participants would recommend the mobile microlearning course to other journalists who want to learn how to write news for mobile audiences. Also, most of the participants agreed that they had learned new things (89%) and had enjoyed learning (76%). Participants described the course as "fun," "interesting," and "short and helpful." One noted the course "provided excellent tips and insights for writing for mobile in a fun and non-time-consuming format." They specifically mentioned "the interactive quizzes, games, and exercises such as writing their own headlines," "multiple-choice questions in the final review section," and "concrete, different, and real-world examples" as useful parts of the course. Adapting Honebein and Honebein (2015), we argue that appeal means students like

the entire MML experience; the positive perceptions in this study indicate that the mobile microlearning course was appealing to the learners. However, some ($n=9$) said that even more practical examples and explanations of the learning concepts would aid in understanding the course content. Additionally, eight participants said that they had had difficulty completing the timed exercises. Overall, the participants' responses confirmed that interactive microcontent, exercises, and instant automated feedback can be valuable design elements for mobile microlessons.

In summary, the results show that the MML course met its goals for learning effectiveness and increased learners' confidence in applying the skills it taught, and that the MML course is efficient and appealing to learners. However, room remains to improve its learning effectiveness for some learners.

Recommended improvements for MML course design

This formative study gives new knowledge on how to design MML courses to increase their efficiency, effectiveness, and appeal.

The first insight refers to our applied MML design principle #4: automated instant feedback. The theory was that automated feedback delivered instantly is useful for learners. In this MML course, the feedback system gave the correct answers to questions in quizzes and exercises; it also provided an explanation for why a specific answer was correct. The automated system worked well when there was only one correct answer. However, for example, when learners were given an open-ended item, such as writing a news headline, the feedback system could offer only one correct headline and explain why it was correct. It could not comment on that learner's particular headline and explain how it could be better. Learners indicated that they wanted personalized feedback so that they were able to understand the gap between what they already knew or learned and where to improve. Accordingly, automated feedback should include more personalized, meaningful, and differentiated feedback, instead of generalized automated feedback, which can be a key point for designing a better feedback system in MML. One option would be to use a chatbot, in which the automated feedback system can be trained through machine learning to give personalized feedback (Smutny and Schreiberova 2020). Other options might include a mix of automated generalized feedback and feedback by an instructor. To keep the self-paced nature of MML, one-time personalized feedback from an instructor could be integrated, allowing learners to request further feedback. Further research is needed.

The second set of new knowledge refers to MML design principle #3: apply learned content in short exercises. Our course applied different types of short exercises in each lesson such as dragging and dropping to add missing words, tapping quote bubbles to chunk a story, or evaluating true or false flash cards. Several of such tasks had a time limit. However, the study indicates that the time span was too short. When there is not sufficient time to understand the instruction or the gamified task, learners may feel frustration, which is counterproductive to learning effectiveness. Future research is needed to explore the time restriction and the learning context to determine how much time is effective for each context. Learners from journalism may have different needs than learners from computer science.

The third insight refers to MML design principle #2: interactive content. This study shows the relevance of combining real-world examples with interactive learning content to increase the appeal of the MML course. Real-world examples are authentic for the learner, are age appropriate, and connect the learner's interests and knowledge with the real world. For example, when learning how to write *concisely*, best practice is to use an example of *wordy* versus *concise* that focuses on things the learner likes and finds interesting. In other words, a real-world example from a relevant news article or social media is more effective than an example from Shakespeare. Through the real-world examples, learners can easily connect their conceptual knowledge to the new situation. Interactive real-world content can be supported with real-life images and a selection of text in which the user applies drag and drop to indicate which image correctly corresponds to which text.

Lastly, MML is meant for the small screens of smartphones, and text that is too long can frustrate the learner. Clear, concise sentences matter. MML does not support the same amount of verbiage that is used in learning management systems designed for desktop or laptop use. Further research is needed to investigate how much content and how to present it for efficient learning. In general, while the recommendations of more information might be logical from the participants' perspective, more examples or longer lessons might be counterproductive to the idea of MML. Further research is needed on the optimal length and level of difficulty for MML lessons. In addition, as Reeves and Lin (2020) say, technology-enhanced learning is always embedded into certain contexts, and studies of MML have to understand the different contexts to foster the learning experiences.

Implications

Our study shows that the 5 Cs mobile microlearning course positively affects learning efficacy by increasing learners' knowledge about writing news for mobile audiences. For MML lessons, which should take no more than 5 min, the study points to the importance of a four-step sequence. These steps are (a) an aha moment, (b) interactive content, (c) short gamified exercises, and (d) instant automated feedback. This study shows that such a microcourse designed in this way can efficiently support learning.

Does this research on mobile microlearning show that MML should be applied in all of higher education as a substitute for other online courses? No, this is not the message. The message is that for certain topics, which are rather small and can be chunked into nugget-size units (e.g., video editing, computer programming, business marketing, etc.), mobile microlearning is useful when applying the four specific instructional flow design principles. However, using MML to convey deeper learning concepts, such as meaningful learning with technologies or other more complex topics, is challenging. According to Howland et al. (2013), meaningful learning supports the higher order thinking of analyzing and creating. For such concepts, cooperative learning is one important element. Meaningful learning goes beyond the lower order thinking skills of recalling facts or understanding. The applied design principles of MML proposed in this article certainly helped learners gain lower order thinking skills, such as remembering the 5 Cs concepts and understanding when and how to apply the concepts to write a mobile headline or a story. However, MML

has limitations in supporting learners with collaborative learning or higher order thinking as it does not offer learners the chance to collaborate with others to expand and solidify their learning in a broader context. Learners do not get the option to analyze, synthesize, or create new *products* in order to develop higher order thinking skills.

Instead, MML fosters learners' *click activities* that support a quick scanning of information rather than constructing deeper knowledge. The issues discussed here contribute to the broader discourse of automating human activities in the digital age (e.g., creating artifacts that think for humans) versus enriching and empowering teachers and students with technologies (e.g., creating artifacts to think with). MML tends to focus on the automation of learning and supports a learning approach where the answer is known, but it may not be useful for learning when the answer is not known. Further research is required.

Despite these limitations, mobile microlearning is not devoid of usefulness. However, it is crucial to remember that it is not the only way of learning. Our world provides complex questions where the answer is not yet known (e.g., challenges of environmental issues), and MML cannot help there, at least not in its current design. We, therefore, encourage mobile microlearning designers and developers to offer different points of entry into learning. For example, one can be the mobile microlearning way (e.g., to make people curious) and another might be a deeper or more meaningful approach. One can build on the other to encourage learners to get into the details. In addition, as shown by Major and Calandrino (2018), a revised mobile microlearning design can go beyond chunking. Their study illustrates how microlearning can be used for deeper learning. In it, students were encouraged to use mobile devices to connect the subject matter with their everyday lives as well as the world around them. Learners uploaded photos or short videos of what they had applied or created, and coaches gave feedback in a timely manner.

Limitations

The results reflect a specific population: journalists seeking to improve professional skills. Moreover, this study was of a quantitative–exploratory nature. Including more participants at a future date to increase the reliability of the results is recommended because the sample size of the current study was only 35 participants. Attempting a similar study across different teaching fields might also be useful. This study did not follow up to check the participants' retained knowledge after weeks or months.

In the study, participants were allowed to access the mobile microcourse whenever they found time in order to mirror the real-world scenario of journalists in the field with a need to know. All participants took the pretest, course, and posttest at their own pace instead of having them all do the pretest on the same day, then take the course at their own pace, and later take the posttest on the same day. Further research is needed to understand how this may or may not affect the study results.

The study adopted the Missouri Department of Education Setting Growth Targets Criteria (2015) and used the 5-Tier pre–post metrics to assess participants' learning growth. Learners in the study were college students and journalism professionals (e.g., journalists and journalism educators), while the original target learners of the Missouri Department of Education Setting were K-12 learners. Future research is needed about the reliability and validity of these pre–post metrics for postsecondary settings.

This course was made for the small screens of smartphones, so the content cannot be long without scrolling. This limitation may impede the ability to follow widely accepted

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168

instructional design principles, for example, how to formulate learning goals and objectives, as the length of text would not fit on the screen. Future research is needed to explore how to design meaningful goals and learning objectives for small screens (cf. Mager 1988).

Conclusion

The study provides evidence that mobile microlearning for journalism education is effective at increasing journalists' skills in writing news for mobile readers. This MML course incorporated several critical design principles of mobile microlearning. The five microlessons, no more than 5 min each, followed a specific sequence of (a) an aha moment that helps the learner grasp the relevance of the topic, (b) interactive content, (c) short exercises, and (d) instant automated feedback. The course supported the learning of the participants, increased their knowledge and skills, and increased their confidence in writing news for mobile audiences.

Results show that mobile microlearning can be effective and efficient in supporting learning and appealing to learners. However, the course was not equally effective for all learners, leaving room for improvement. Future research on mobile microlearning could consider the specific design principles proposed in this study as applied to a broader audience or other professional fields.

Appendix

See Table 9.

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Table 9 An outline of the instructional sequence of a mobile microcourse titled *"The 5 Cs of writing news for mobile audiences"* (5 min per lesson) and the study process

Process	Instructional sequence	Course activities
Step 1	Set up the app and join the course	Download the mobile learning EdApp, and log in to take the course
	START HERE	A quick guide to navigating your lessons
	Precourse survey	
	Pretest	
Step 2	Lesson 1: Be conversational (Postlesson survey)	Short text instructions, images, animations, interactive activity (rubbing images to reveal the content; drag and drop sentence construction, chatting box), text-based multiple choice, instant feedback box
	Lesson 2: Be considerate (Postlesson survey)	Short text instructions, aha moment images, interactive activity (rubbing images to reveal the content; drag and drop sentence construction), gamified quizzes (timed true or false, image slider), image-based and text-based multiple choices, instant feedback box
	Lesson 3: Be concise (Postlesson survey)	Short text instructions, images, gamified activity (strike out wordy phrases and reveal a concise replacement), gamified quizzes (matrix connection), bite-size review of previous lessons, instant feedback box
	Lesson 4: Be contextual (Postlesson survey)	Short text instructions, images, gamified quizzes (finding missing words, timed true or false, rubbing images to reveal the content), text-based multiple choices, instant feedback box
	Lesson 5: Be chunky (Postlesson survey)	Short text instructions, images, image-based and text-based multiple choices, interactive activity (rubbing images to reveal the content, tapping images to explore the content), gamified quizzes (timed true or false, tapping quote bubbles to chunk a story)
Step 3	Course review	
	Posttest	
	Postcourse survey	

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References

Ahmad, N. (2018). Effects of gamification as a micro learning tool on instruction. *E-Leader International Journal, 13*(1), 1–9.

Aitchanov, B., Zhaparov, M., & Ibragimov, M. (2018). The research and development of the information system on mobile devices for micro-learning in Educational Institutes. *Proceedings of 2018 14th International Conference on Electronics Computer and Computation (ICECCO)* (pp. 1–4). https://doi.org/10.1109/ICECCO.2018.8634653.

Andoniou, C. (2017). *Technoliterati: Digital explorations of diverse micro-learning experiences* (7). Resource document. https://dspace.adu.ac.ae/handle/1/1141. Accessed 7 November 2017.

Baehr, C. M., Baehr, C., & Schaller, B. (2010). *Writing for the Internet: A guide to real communication in virtual space. ABC-CLIO*. Santa Barbara, California: Greenwood Press.

Baek, Y., & Touati, A. (2017). Exploring how individual traits influence enjoyment in a mobile learning game. *Computers in Human Behavior, 69,* 347–357.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*(2), 191–215.

Bandura, A. (2010). *Self-efficacy. The Corsini encyclopedia of psychology*. Hoboken, NJ: Wiley.

Benesty, J., Chen, J., Huang, Y., & Cohen, I. (2009). Pearson correlation coefficient. In *Noise reduction in speech processing*. Berlin: Springer. https://doi.org/10.1007/978-3-642-00296-0_5.

Berge, Z. L., & Muilenburg, L. (Eds.). (2013). *Handbook of mobile learning*. New York: Routledge.

Boyatzis, R. E. (1998). *Transforming qualitative information: Thematic analysis and code development*. Thousand Oaks, CA: Sage.

Brom, C., Levčík, D., Buchtová, M., & Klement, D. (2015). Playing educational micro-games at high schools: Individually or collectively? *Computers in Human Behavior, 48,* 682–694.

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18*(1), 32–41.

Bursztyn, N., Shelton, B., Walker, A., & Pederson, J. (2017). Increasing undergraduate interest to learn geoscience with GPS-based augmented reality field trips on Student's own smartphones. *GSA Today, 27*(6), 4–10.

Burton, R. F., & Miller, D. J. (1999). Statistical modelling of multiple-choice and true/false tests: Ways of considering, and of reducing, the uncertainties attributable to guessing. *Assessment & Evaluation in Higher Education, 24*(4), 399–411.

Cairnes, R. (2017). *Beyond the hype of micro learning: 4 steps to holistic learning.* Resource document. https://www.insidehr.com.au/hype-micro-learning-4-steps-holistic-learning/. Accessed 14 October 2017.

Callisen, L. (2016). *Why micro learning is the future of training in the workplace*. Resource document. https://elearningindustry.com/micro-learning-future-of-training-workplace. Accessed 14 October 2017.

Cates, S., Barron, D., & Ruddiman, P. (2017). MobiLearn go: Mobile microlearning as an active, location-aware game. *Proceedings of the 19th International Conference on Human–Computer Interaction with Mobile Devices and Services* (pp. 1–7). https://doi.org/10.1145/3098279.3122146.

Clark, R. E. (1994). Media will never influence learning. *Educational Technology Research and Development, 42*(2), 21–29.

Clark, H., Jassal, P. K., Van Noy, M., & Paek, P. L. (2018). A new work-and-learn framework. In D. Ifenthaler (Ed.), *Digital workplace learning* (pp. 23–41). New York: Springer.

Dai, H., Tao, Y., & Shi, T. W. (2018). Research on mobile learning and micro course in the big data environment. *Proceedings of the 2nd International Conference on E-Education, E-Business and E-Technology* (pp. 48–51).

Decker, J., Hauschild, A. L., Meinecke, N., Redler, M., & Schumann, M. (2017). Adoption of micro and mobile learning in German enterprises: A quantitative study. *Proceedings of European Conference on e-Learning* (pp. 132–141).

Dingler, T., Weber, D., Pielot, M., Cooper, J., Chang, C.-C., & Henze, N. (2017). Language learning on-the-go: Opportune moments and design of mobile microlearning sessions. *Proceedings of the 19th International Conference on Human–Computer Interaction with Mobile Devices and Services* (pp. 1–12). https://doi.org/10.1145/3098279.3098565.

Emerson, L. C., & Berge, Z. L. (2018). Microlearning: Knowledge management applications and competency-based training in the workplace. *Knowledge Management & E-Learning: An International Journal, 10*(2), 125–132.

Eng, J. (2003). Sample size estimation: How many individuals should be studied? *Radiology, 227*(2), 309–313.

Fang, Q. (2018). A study of college English teaching mode in the context of micro-learning. *Proceedings of the 2018 International Conference on Management and Education, Humanities and Social Sciences (MEHSS 2018)* (pp. 235–239). https://doi.org/10.2991/mehss-18.2018.50.

Fiore, S. M., Graesser, A., Greiff, S., Griffin, P., Gong, B., Kyllonen, P., et al. (2017). *Collaborative problem solving: Considerations for the national assessment of educational progress*. Washington, D.C.: National Center for Education Statistics.

Gagne, R. M., Briggs, L. J., & Wager, W. W. (1992). *Principles of instructional design* (4th ed.). Fort Worth, TX: Harcourt Brace Jovanovich College Publishers.

Giurgiu, L. (2017). Microlearning an evolving elearning trend. *Scientific Bulletin, 22*(1), 18–23.

Göschlberger, B., & Bruck, P. A. (2017). Gamification in mobile and workplace integrated microLearning. *Proceedings of iiWAS '17: The 19th International Conference on Information Integration and Web-based Applications & Services* (pp. 545–552). https://doi.org/10.1145/3151759.3151795.

Grant, M. M. (2019). Difficulties in defining mobile learning: Analysis, design characteristics, and implications. *Educational Technology Research and Development, 67*(2), 361–388.

Honebein, P. C., & Honebein, C. H. (2015). Effectiveness, efficiency, and appeal: Pick any two? The influence of learning domains and learning outcomes on designer judgments of useful instructional methods. *Educational Technology Research and Development, 63*(6), 937–955.

Howland, J. L., Jonassen, D. H., & Marra, R. M. (2013). *Meaningful learning with technology: Pearson new international edition*. New York: Pearson Higher Ed.

Hui, B. I. A. N. (2014). Application of micro-learning in physiology teaching for adult nursing specialty students. *Journal of Qiqihar University of Medicine*, *21*(61), 3219–3220.

Jahnke, I., Lee, Y. M., Pham, M., He, H., & Austin, L. (2019). Unpacking the inherent design principles of mobile microlearning. *Technology, Knowledge and Learning, 25*(3), 585–619.

Jing-Wen, M. (2016). A design and teaching practice of micro mobile learning assisting college English teaching mode base on WeChat public platform. *Conference Proceedings of 2016 2nd International Conference on Modern Education and Social Science* (pp. 250–255). https://doi.org/10.12783/dtssehs/mess2016/9595.

Jonassen, D. H., Campbell, J. P., & Davidson, M. E. (1994). Learning with media: Restructuring the debate. *Educational Technology Research and Development, 42*(2), 31–39.

Kabir, F. S., & Kadage, A. T. (2017). ICTs and educational development: The utilization of mobile phones in distance education in Nigeria. *Turkish Online Journal of Distance Education, 18*(1), 63–76.

Khurgin, A. (2015). *Will the real microlearning please stand up? Association for Talent Development.* Resource document. https://www.td.org/insights/will-the-real-microlearning-please-stand-up. Accessed 21 January 2018.

Kovacs, G. (2015). FeedLearn: Using Facebook feeds for microlearning. *Proceedings of the 33rd Annual ACM Conference Extended Abstracts on Human Factors in Computing Systems* (pp. 1461–1466). https://doi.org/10.1145/2702613.2732775.

Kozma, R. B. (1994). Will media influence learning? Reframing the debate. *Educational Technology Research and Development, 42*(2), 7–19.

Kozma, R. (2000). Reflections on the state of educational technology research and development. *Educational Technology Research and Development, 48*(1), 5–15.

La Barge, G. (2007). Pre-and post-testing with more impact. *Journal of extension*, *45*(6). Resource document. https://www.joe.org/joe/2007december/iw1.php. Accessed 11 December 2018.

Liao, K. (2015). *PressToPronounce: An output-oriented approach to mobile language learning.* (Doctoral dissertation, Massachusetts Institute of Technology). Retrieved from http://hdl.handle.net/1721.1/100628.

Mager, R. (1988). *Making instruction work*. Belmont, CA: Lake Publishing Co.

Major, A., & Calandrino, T. (2018). Beyond chunking: Micro-learning secrets for effective online design. *FDLA Journal*, *3*(1), Article 13, 1–5.

McKenney, S., & Reeves, T. (2018). *Conducting educational design research*. New York: Routledge.

Missouri Department of Elementary & Secondary Education. (2015). *Setting growth targets for student learning objectives: Methods and considerations*. Resource document. https://dese.mo.gov/sites/default/files/Methods-and-Considerations.pdf. Accessed 29 March 2020.

Montgomery, M. (2007). *The discourse of broadcast news: A linguistic approach*. New York: Routledge.

Nickerson, C., Rapanta, C., & Goby, V. P. (2017). Mobile or not? Assessing the instructional value of mobile learning. *Business and Professional Communication Quarterly, 80*(2), 137–153.

Nikou, S. A., & Economides, A. A. (2018a). Mobile-based micro-learning and assessment: Impact on learning performance and motivation of high school students. *Journal of Computer Assisted Learning, 34*(3), 269–278.

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Nikou, S. A., & Economides, A. A. (2018b). Mobile-based assessment: A literature review of publications in major referred journals from 2009 to 2018. *Computers & Education, 125,* 101–119.

Park, M. H. (2009). *Comparing group means: t-tests and one-way ANOVA using Stata, SAs, R, and SPSS*. Working paper, Centre for Statistical and Mathematical Computing, Indiana University. Resource document. https://scholarworks.iu.edu/dspace/handle/2022/19735. Accessed 25 October 2017.

Park, Y., & Kim, Y. (2018). A design and development of micro-learning content in e-learning system. *International Journal on Advanced Science, Engineering and Information Technology, 8*(1), 56–61.

PowerSchool. (2016). *There's one thing you need to do now to show student growth*. Resource document. https://www.powerschool.com/resources/blog/theres-one-thing-need-now-show-student-growth/. Accessed 20 April 2020.

Reigeluth, C. M., & Carr-Chellman, A. A. (Eds.). (2009). *Instructional-design theories and models, volume III: Building a common knowledge base* (Vol. 3). New York: Routledge.

Reigeluth, C. M., & Frick, T. W. (1999). Formative research: A methodology for creating and improving design theories. In C. Reigeluth (Ed.), *Instructional-design theories and models. A new paradigm of instructional theory* (Vol. II, pp. 633–651). Mahwah, NJ: Lawrence Erlbaum Associates.

Reeves, T. C., & Lin, L. (2020). The research we have is not the research we need. *Educational Technology Research and Development, 68*(4), 1991–2001. https://doi.org/10.1007/s11423-020-09811-3.

Shadiev, R., Hwang, W. Y., & Liu, T. Y. (2018). Investigating the effectiveness of a learning activity supported by a mobile multimedia learning system to enhance autonomous EFL learning in authentic contexts. *Educational Technology Research and Development, 66*(4), 893–912.

Simons, L. P., Foerster, F., Bruck, P. A., Motiwalla, L., & Jonker, C. M. (2015). Microlearning mApp raises health competence: Hybrid service design. *Health and Technology, 5*(1), 35–43.

Sirwan Mohammed, G., Wakil, K., & Sirwan Nawroly, S. (2018). The effectiveness of microlearning to improve students' learning ability. *International Journal of Educational Research Review, 3*(3), 32–38.

Skalka, J., & Drlík, M. (2018). Educational model for improving programming skills based on conceptual microlearning framework. *Proceedings of International Conference on Interactive Collaborative Learning* (pp. 923–934). https://doi.org/10.1007/978-3-030-11932-4_85.

Smutny, P., & Schreiberova, P. (2020). Chatbots for learning: A review of educational chatbots for the Facebook Messenger. *Computers & Education*. https://doi.org/10.1016/j.compedu.2020.103862.

Sun, G., Cui, T., Beydoun, G., Chen, S., Dong, F., Xu, D., & Shen, J. (2017). Towards massive data and sparse data in adaptive micro open educational resource recommendation: A study on semantic knowledge base construction and cold start problem. *Sustainability, 9*(6), 1–21.

Traxler, J. (2005). Defining mobile learning. *Proceedings of In IADIS International Conference Mobile Learning* (pp. 261–266). Online: IADIS Press.

Umair, S. (2016). Mobile reporting and journalism for media trends, news transmission and its authenticity. *Journal of Mass Communication and Journalism, 6,* 323–328.

Wenger, D., Owens, L., & Thompson, P. (2014). Help wanted: Mobile journalism skills required by top US news companies. *Electronic News, 8*(2), 138–149.

Yang, L., Zheng, R., Zhu, J., Zhang, M., Liu, R., & Wu, Q. (2018). Green city: An efficient task joint execution strategy for mobile micro-learning. *International Journal of Distributed Sensor Networks, 14*(6), 1–14. https://doi.org/10.1177/1550147718780933.

Zheng, W. (2015). Design of mobile micro-English vocabulary system based on the Ebbinghaus forgetting theory. *Proceedings of Internet Computing for Science and Engineering (ICICSE), 2015 Eighth International Conference* (pp. 241–246). https://doi.org/10.1109/ICICSE.2015.51.

Zheng, R., Zhu, J., Zhang, M., Liu, R., Wu, Q., & Yang, L. (2019). A novel resource deployment approach to mobile microlearning: From energy-saving perspective. *Wireless Communications and Mobile Computing, 2019,* 1–15. https://doi.org/10.1155/2019/7430860.

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Appendix 5–Instruments: Pre-and-Post Testing Items of Study 4

Items of the Pre-Test and Post-Tests in Study 4

(*Note.* Both the pre-test and post-test applied the same 10 multiple-choice questions.

Each question item is 10 points. The total score is 100 points of each test.)

Instruction: The better headline doubled click-through at chicagotribune.com. Choose the better head in each pair. Ready. Set. Go.

A. Pick the better headline:
Q1:
a. Huge North Shore school referendum got legislative help, splits community.
b. North Shore school district's $198M referendum causing "a civil war in Highland Park"

Q1-a. For the previous question, did you know the answer, or were you guessing?
      (a) I know the answer
      (b) I was guessing

Q2:
a. Poison pills, noise cannons: Researchers use arsenal of weapons to fight Asian carp.
b. Deploying multiple tools key to stopping Asian crap advance, researchers say.

Q2-a. For the previous question, did you know the answer, or were you guessing?
      (a) I know the answer
      (b) I was guessing

Q3:
a. Some of the world's most expensive beef on sale at River North restaurant.
b. Rare A5 wagyu at Roka Akor.

Q3-a. For the previous question, did you know the answer, or were you guessing?
      (a) I know the answer
      (b) I was guessing

Q4:
a. Study: Think twice before buying breast milk online.
b. Most breast milk sold online contains dangerous bacteria: study.

Q4-a. For the previous question, did you know the answer, or were you guessing?
      (a) I know the answer
      (b) I was guessing

Q5:
a. Man found in burning garage identified.
b. Gary man who was acquitted of murder ID'ed as man found in burning van.

Q5-a. For the previous question, did you know the answer, or were you guessing?
      (a) I know the answer
      (b) I was guessing

Q6:
a. Two charged in death of man found buried on Southwest Side.
b. Dad, daughter charged in dismemberment death.

Q6-a. For the previous question, did you know the answer, or were you guessing?
    (a) I know the answer
    (b) I was guessing

Q7:
a. Exelon teams up with Big Coal in subsidy-filled Springfield bill.
b. Illinois energy bill may cost consumers an additional $24 billion, opponent say.

Q7-a. For the previous question, did you know the answer, or were you guessing?
    (a) I know the answer
    (b) I was guessing

Q8:
a. Made from scratch on Chicago.
b. Chicago firm craft guitars for U2, Black Sabbath.

Q8-a. For the previous question, did you know the answer, or were you guessing?
    (a) I know the answer
    (b) I was guessing

Q9:
a. Chicago student's meningitis death closes school.
b. Lindblom academy closed today after student, 16, dies of meningitis.

Q9-a. For the previous question, did you know the answer, or were you guessing?
    (a) I know the answer
    (b) I was guessing

B: Which of these can be used to chunk stories?
Q10:
(Pick as many as apply)
a. Bolded words
b. Bulleted or numbered lists
c. Subheads
d. Paragraphs of five or more sentences

Q10-a. For the previous question, did you know the answer, or were you guessing?
   (a) I know the answer
    (b) I was guessing

Appendix 6–Examples of the Developed Mobile Microcourse Contents

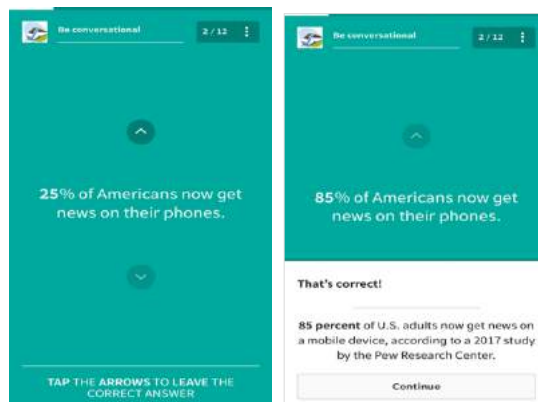The MML course designs were based on the recommendations and results of previous stages'

studies.

Design Example 1-Designing for an A-ha moment to help learners understand the relevance of the
learning topic.
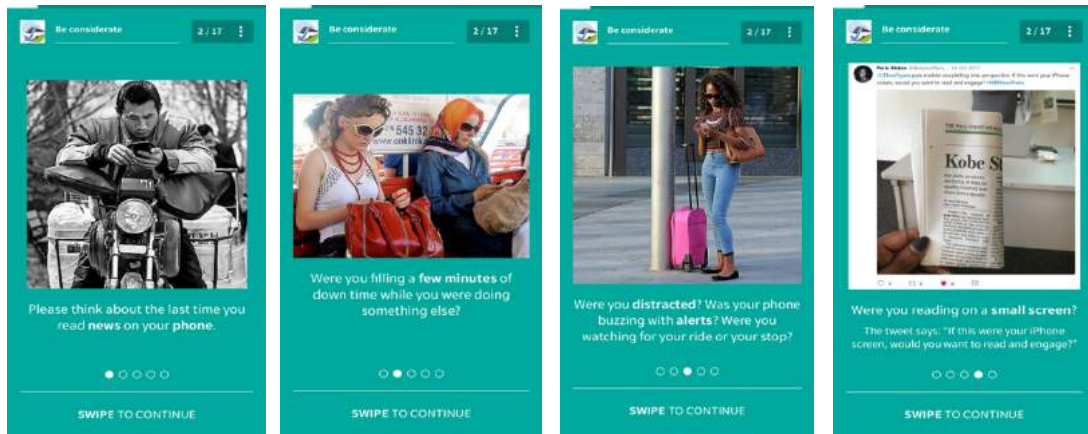
Design Example 2-Designing a short gamified quiz (True-or-False).
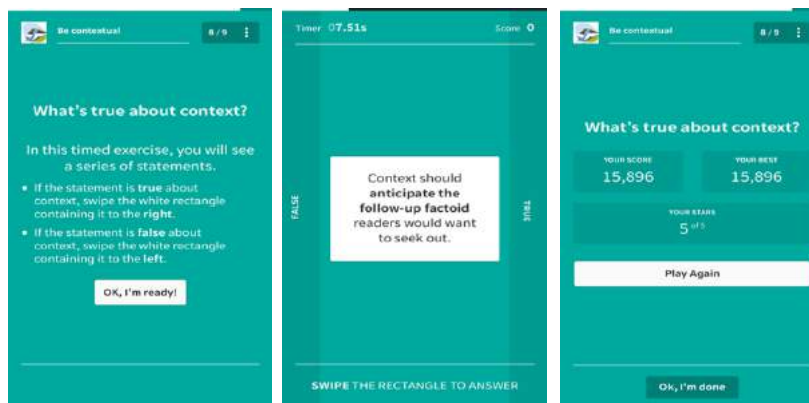
Design Example 3-Designing a focused burst and instant feedback system.

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