



## Research article

## Features, barriers, and influencing factors of mobile learning in higher education: A systematic review

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## ABSTRACT

Mobile devices are not only a tool for communication, but also a powerful instrument for the economy, mass communication, and learning. Because the use of mobile devices and the Internet is growing rapidly, these tools are increasingly being utilized in learning and instruction. It is therefore important to investigate how mobile devices can be applied in learning. This article focuses on analyzing the features of mobile learning as well as the barriers and influencing factors of using mobile devices in learning. It pays particular attention to clarifying the factors, techniques, and strategies that enhance learners' experiences in using mobile devices. It reports a systematic review that examined studies published in 2006–2018 containing the keywords “mobile learning” “m-learning”, “undergraduate students” and/or “higher education.” The results of the review indicated mobile devices can be used as learning tools for tasks such as submitting homework, reflecting on immediate learning experiences, and sharing ideas. Instructors should consider three main components in mobile learning: learners' and instructors' readiness, learning management and supporting systems.

## 1. Introduction

Higher education graduates are increasingly expected to think creatively, solve problems systematically, and engage in rational critique. However, classroom instruction may not be sufficient for improving these important thinking skills. Because of rapid technological evolution, instructors need to create learning environments for developing practical skills and simulating real work experiences. Mobile device use has become nearly universal worldwide, which can be seen from the increase in the number of mobile subscriptions per 100 people, from 12.075 in 2000 to 98.622 in 2015 (World Bank, 2016). Thus, it is not surprising that mobile devices are increasingly used for pedagogical purposes (Gan and Balakrishnan, 2017).

The educational policy of the United Nations' Educational, Scientific and Cultural Organization (UNESCO, 2011) has foreseen mobile devices as important tools in learning. While skills such as creative and critical thinking or problem solving are increasingly emphasized, mobile devices are likely to be prominent among 21st century learning tools. Smartphones in particular have several features that make them promising as learning devices (Davies et al., 2012; Mohammad et al., 2012), particularly their portability and their facilitation of rapid retrieval of

information, collaborative learning, situated learning, and other learning strategies (Gikas and Grant, 2013).

## 1.1. Mobile learning

An educational technology scholar (Quinn, 2012) has noted four key aspects of mobile devices: input, sensing, output, and connectivity. Each aspect of a given device should be taken into account in the design of appropriate learning activities. Input methods include touch, voice, keyboard input, and others (Quinn, 2012). Sensing through various channels, such as touch screen, camera, microphones, or GPS (McQuiggan et al., 2015) enables recording of diverse types of data into the device (Quinn, 2012). Output components include the screen, speakers, and earphones, which provide output through video, images, text, and audio. Such output is activated by input through the touch screen, keyboard, or voice recognition (Advanced Distributed Learning, 2013; Quinn, 2012). Connectivity relates to how the device connects to a network or other tools for operating applications. Continuous network access enables cloud-based storage (Quinn, 2012). Such systems encourage learners to learn in any place outside the classroom and connect their learning experience with online information (Wong et al., 2015).

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Mobile devices have been described as tools for accessing resources (Kukulka-Hulme, 2005; Wong et al., 2015). Learners can find more information by using search engines or various applications such as those providing news feed or language learning functionalities and share their ideas with other learners through social media. However, mobile devices are not only a tool for accessing resources, but also for connecting users engaged in activities and simultaneous experiences. Learning activities that are facilitated by mobile devices include searching for and accessing documents, doing surveys, summarizing content, reading books, recording videos, taking photos, sharing information, and note taking, to name a few (McQuiggan et al., 2015; Sampson et al., 2013). Because of the small size of contemporary mobile devices, they can easily be brought in and out of a classroom and used as a learning tool (McQuiggan et al., 2015).

The application of mobile devices in learning began around 1995, when they were mostly used for accessing electronic documents. In this first phase, the focus was only on the devices themselves, particularly on their features and functions. In this article, “features” refers to the characteristics of mobile device hardware, such as size, shape, material, and color (Han et al., 2004) or of their software (Parsons et al., 2007). “Functions,” in contrast, refers to actions that can be performed on mobile devices, for example connecting to the Internet or retrieving information (Kroski, 2008; Rotheram-Borus et al., 2012). In the following decade, increasing attention was paid to their use in informal or non-formal education (Crompton, 2013; Pachler et al., 2010; Unwin, 2015).

Increasing access to smartphones makes them invaluable in non-formal education (UNESCO, 2011). In formal education, undergraduate programs increasingly involve students using them for classroom activities (Chukwuere and Ifeanyi, 2018; Fuller and Joynes, 2015; Jesse, 2015). Given increasing mobile device usage and the evolution of mobile connectivity to 5G technologies, it has been projected that 5 billion people will be accessing the internet on mobile devices by 2025 (GSM Association, 2019). Although mobile learning is known as a learning channel among people who have technology readiness, the use of this channel requires appropriate infrastructure and the educators to have basic instructional skills (UNESCO, 2011). Many countries, such as China, Singapore, Taiwan, or Malaysia, have been preparing their infrastructure and supporting the use of mobile devices in various domains of the education sector (UNESCO, 2012). In developing countries, language learning has been one key area for applying mobile devices (Allothman et al., 2017). While investing in infrastructure, governments and educational institutes also need to consider the ability of instructors to apply mobile technologies in the classrooms (Koehler and Mishra, 2009).

Using mobile devices in the classroom makes personalized learning more manageable. Personalized learning is another term for self-directed learning (Crompton, 2013), which entails that learners should be able to set their learning goals and milestones, evaluate their progress, choose their own learning channels, and access desirable materials. Mobile devices allow learners to complete these tasks at their own pace and based on their own choices (Sampson et al., 2013). Therefore, learning experiences via mobile devices depend on individual goals or demands, and various learning styles of learners (Herrington et al., 2009).

Mobile devices also make situated learning possible, in other words, learning in real-life contexts while searching related information to validate information or to enhance the in-site experience (Cheon et al., 2012; Domingo and Garganté, 2016; Gikas and Grant, 2013). The emerging Internet of Things (IoT) provides further opportunities for enhancing learning experiences (Dachyar et al., 2019). Therefore, learning spaces now extend beyond the classroom (Sampson et al., 2013), as mobile learning can take place whenever and wherever (Pachler et al., 2010).

## 1.2. Instructional design

Instructors using mobile devices should not only consider the functionalities of the available devices but pay particular attention to instructional design in order to facilitate learning strategies that encourage learners to use their devices for appropriate activities (Alioun and Delialioglu, 2015; Kearney et al., 2015; Lee et al., 2016; Nedungadi and Raman, 2012), such as group work or discussion (Gikas and Grant, 2013), drawing mind maps (Hwang et al., 2011), or taking exams (Godfrey, 2016; Morris et al., 2016).

Instructors applying mobile devices as learning tools should examine learning styles, learners' interest and motivation, the learning environment, technology readiness, learning objectives, learning activities, and other conditions (Sampson et al., 2013). First of all, instructors should realize learners' readiness to use mobile devices; it is an important factor determining the effectiveness of mobile learning (Shorfuzzaman and Alhussein, 2016). Analyzing learners' characteristics and learning styles is also required for designing appropriate learning activities (Gagne et al., 2004; Gustafson and Branch, 2002; Smaldino et al., 2006).

Instructional design (ID) is a powerful process of designing appropriate instruction for learners before it is implemented in the learning context (Richey et al., 2011). Instructors need to follow these design steps: analysis of learners, examination of the context, development of materials, and evaluation of both formative and summative kinds (Gustafson and Branch, 2002). The acronym ADDIE summarizes the key elements of analysis, design, development, implementation, and evaluation (Gagne et al., 2004). The purpose of analysis is to identify and understand the current context and its constraints: Instructors need to examine learners' characteristics, prior knowledge, learning context, learning objectives, contents, and learning materials (Gagne et al., 2004; Gustafson and Branch, 2002; Richey et al., 2011). After analysis, instructional designers or instructors design instruction, beginning with identifying the learning objectives, scope of content, possible learning activities, and learning materials (Gunter et al., 1995; Morrison et al., 2011). The third step, development, involves setting up the system or platform to be used, or creating learning materials (Wang and Hsu, 2009); this step often involves collaboration between an instructional designer, content experts, and a media production team (Yueh et al., 2014) to create effective learning materials. When the media or application (in case of mobile learning) have been finalized, they will be published on an operating system. After that, the learning activities can be implemented and evaluated through formative and summative evaluation (Clinton and Hokanson, 2012; Richey et al., 2011; Wang and Hsu, 2009).

Although instructional designers have cooperated with instructors in planning and designing effective instruction, some difficulties have been reported in applying mobile devices in learning activities. Given the level of complexity of the operating systems and the variety of applications, instructional design might need to consider the capacity of mobile devices and the optimal elements of mobile learning for maximizing the potential of mobile learning. Consequently, an integrated understanding of both mobile learning and instructional design is crucial for creating effective mobile learning courses (Gedik et al., 2012; Shuler et al., 2013).

Problems and barriers have been reported when learning takes place using applications on mobile devices due to technical reasons (Witt et al., 2016), such as the size of the keyboard and the screen (Cheon et al., 2012; So, 2016), or an unstable internet connection (Koç et al., 2016; Yousafzai et al., 2016). Learning designers or instructors thus need to examine the relevant factors in integrating mobiles in instruction and for managing courses effectively. Furthermore, education administrators, especially in developing countries, should consider the infrastructure needed for applying mobile devices in their institutes, such as Wi-fi,

internet connection, training for using mobile devices in education, and others (Mohammad et al., 2012).

In order to initiate the powerful mobile learning process, the instructors should have information about the features and functions of the available mobile devices, appropriate learning strategies, and instructional design processes for developing the mobile learning class. Understanding features of mobile devices, as well as the barriers, advantages, and appropriate learning strategies are of key importance in facilitating effective mobile learning. For this reason, this systematic review maps and describes the important indicators and features of mobile learning.

### 1.3. Research questions

Two research questions set the direction and scope of the present review:

1. What are the features of mobile devices, appropriate learning strategies, factors influencing mobile learning, as well as barriers of using mobile devices in higher education courses of instruction, adult learning and professional development, and informal education?
2. What tools do instructors use in mobile learning sessions?

## 2. Method

This systematic review aimed to map and describe the features and functions of mobile devices and their application in mobile learning in higher education contexts, including undergraduate and graduate degree courses, adult education and professional development of university staff, as well as informal education.

### 2.1. Search procedure

The scope and topics of research articles to be included in the systematic review were based on the research questions (Littell et al., 2008). The search terms used in this review were “mobile learning”, “m-learning”, “undergraduate students”, and “higher education”. The following databases were used to conduct the search: (1) ERIC, (2) Elsevier, (3) SAGE, (4) Wiley, (5) Springer, and (6) JSTOR.

### 2.2. Selection criteria

The initial search yielded over 30,000 research studies on mobile learning in higher education. Studies were initially retained for the final content analysis if they fulfilled the following two criteria:

- 1) The articles had to be conducted with undergraduate or graduate students at a university or with employees of a higher education organization.
- 2) The studies had to use mobile devices for facilitating learning with their participants.

The title, keywords, abstract and methodology of each article were examined to exclude studies that did not meet these inclusion criteria. Articles were included only if they were published in publications with rankings in the first quartile on SCImago and Web of Science, such as *Computers in Human Behavior*, *Computers & Education*, *Internet and Higher Education*, or the *British Journal of Educational Technology*. Studies were included if they were published between 2006 and February 2018. Mobile learning is a rapidly evolving field, so older studies were excluded because their findings may no longer be applicable to current mobile learning contexts. In total, 78 studies matched the narrowed selection criteria. The citation for each study is listed in Table 1, grouped by the type of learners involved (the reference list provides the corresponding bibliographic details of the studies). The characteristics of the studies are described in the text body of the Results section.

### 2.3. Data analysis and synthesis

After studying the details of each article, content analysis was conducted. The studies were coded for the following categories: researcher and year of publication, objectives, sample, methodology, treatment, and findings. To answer the research questions, the methodology, data treatment, and findings were analyzed in detail and summarized in terms of frequency of studies describing a particular facet. Following Littell et al. (2008), the review procedure consisted of the following stages: 1) coding (gathering data from research studies into an analytic table in a spreadsheet program); 2) screening information about learning, learning tools, activities, barriers in mobile learning, and influencing factors in mobile learning; 3) counting frequencies of matching codes and making within-code comparisons, and 4) describing the results. The analysis was performed by the sole author of the study.

## 3. Results

### 3.1. Study characteristics

The findings indicated that most of the studies on mobile learning conducted in 2006–2018 used quantitative methodology, including experiments ( $n = 20$ ), surveys ( $n = 14$ ), and structural equation modeling ( $n = 10$ ). Some used mixed methods ( $n = 7$ ). Two used the research-and-

**Table 1.** Participant group of interest in the reviewed studies.

Participant group	Study
Undergraduate students	Al-Emran et al., 2016; Al-Otaibi et al., 2016; Alioon and Delialioğlu, 2015; Althunibat, 2015; Barbosa et al., 2012; Bellina and Missoni, 2011; Boulos et al., 2006; Briz-Ponce et al., 2017; Chang et al., 2016; Cheon et al., 2012; Cho et al., 2017; Chuang, 2015; Crane et al., 2011; Davies et al., 2012; Felisoni and Godoi, 2018; Fitzpatrick et al., 2012; Fouh et al., 2014; Frank and Kapila, 2017; Fuller and Joynes, 2015; Gikas and Grant, 2013; Gromik, 2012; Heffin et al., 2017; Jeno et al., 2017; Karimi, 2016; Kim et al., 2017; Koç et al., 2016; Kuznekoff et al., 2015; Kuznekoff and Titsworth, 2013; Lackovic et al., 2017; Lam and Duan, 2012; Lan et al., 2012; Lin and Lin, 2015; Martí and Ferrer, 2012; Masters et al., 2016; Molinillo et al., 2018; Morris, 2010; Morris et al., 2016; Mu and Paparas, 2015; Nayak, 2018; Neyem et al., 2011; O'Bannon and Thomas, 2015; Oberer and Erkollar, 2013; Ooi et al., 2018; Park et al., 2012; Parsazadeh et al., 2018; Pimmer et al., 2013, 2014, 2016, 2016; Sánchez-Prieto et al., 2017; Scott et al., 2017; Shorfuzzaman and Alhussein, 2016; So, 2016; Sobaih et al., 2016; Solly and Matthews, 2011; Terras and Ramsay, 2012; Thomas and Fellowes, 2016; Wakefield et al., 2018; Wang, 2016; Witt et al., 2016
Graduate students	Jahnke and Liebscher, 2013; Ling et al., 2014
Adult learning and professional development	Christensen and Knezek, 2018; Ciampa, 2014; Domingo and Garganté, 2016; Ekanayake and Wishart, 2015; Gu, 2016, 2016; Gu et al., 2014; Jarrahi et al., 2017; Kearney et al., 2015; Leinonen et al., 2016; Mori and Harada, 2010; Zhang et al., 2016
Informal education	Chen, 2018; Gu et al., 2014; Gu et al., 2011; Jones et al., 2013; Merchant, 2012; Neyem et al., 2011; Seta et al., 2014

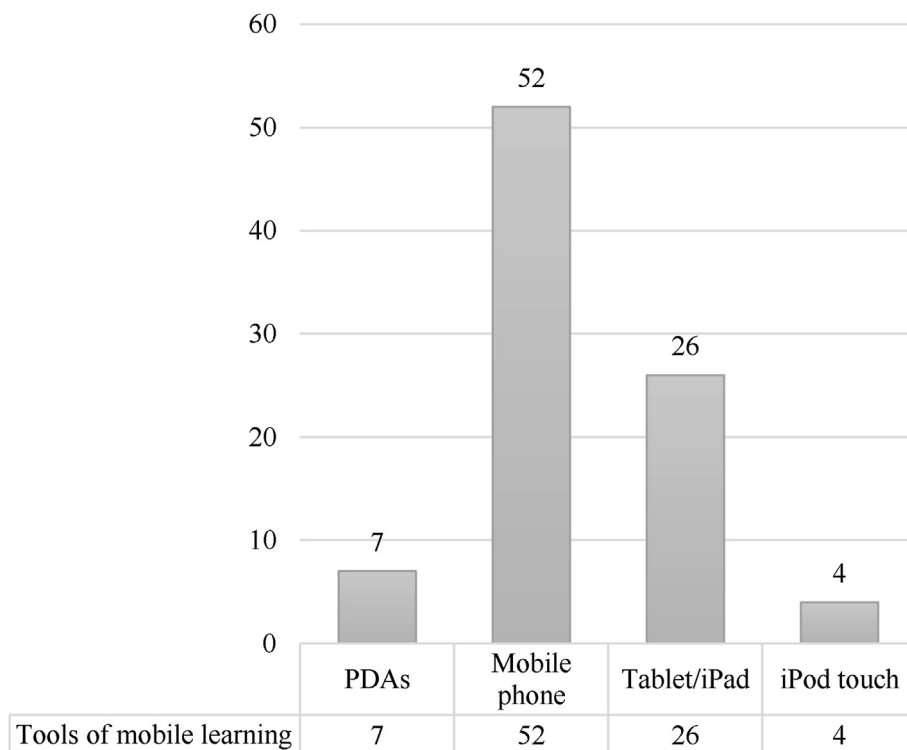


Figure 1. Tools of mobile learning.

development approach ( $n = 2$ ). The rest used qualitative methods ( $n = 25$ ), including case studies, content analyses, and systematic reviews. Most were conducted on undergraduate students ( $n = 59$ , while a minority investigated adult learning and professional development ( $n = 12$ ), informal education ( $n = 7$ ), or graduate students ( $n = 2$ ), as shown in Table 1.

### 3.2. Tools and features of mobile learning

As summarized in Figure 1, the studies included in the systematic review investigated four kinds of tools for mobile learning: 1) mobile

phones ( $n = 52$ ), 2) tablets or iPads ( $n = 26$ ), 3) personal digital assistants PDAs ( $n = 7$ ), and 4) the iPod touch ( $n = 4$ ). Given the ubiquity of such mobile devices, they are a part of our daily lives now; consequently, they enable learners to access online information quickly anywhere and at any time (O'Bannon and Thomas, 2015). As a result, learning also can take place anywhere and at any time (Shorfuzzaman and Alhussein, 2016). Learners are able to bring them everywhere and also use them for functions such as taking photos and sharing them immediately (Al-Emran et al., 2016). There is a trend of decreasing size in the devices; for example, including a transition from tablets to smart phones.

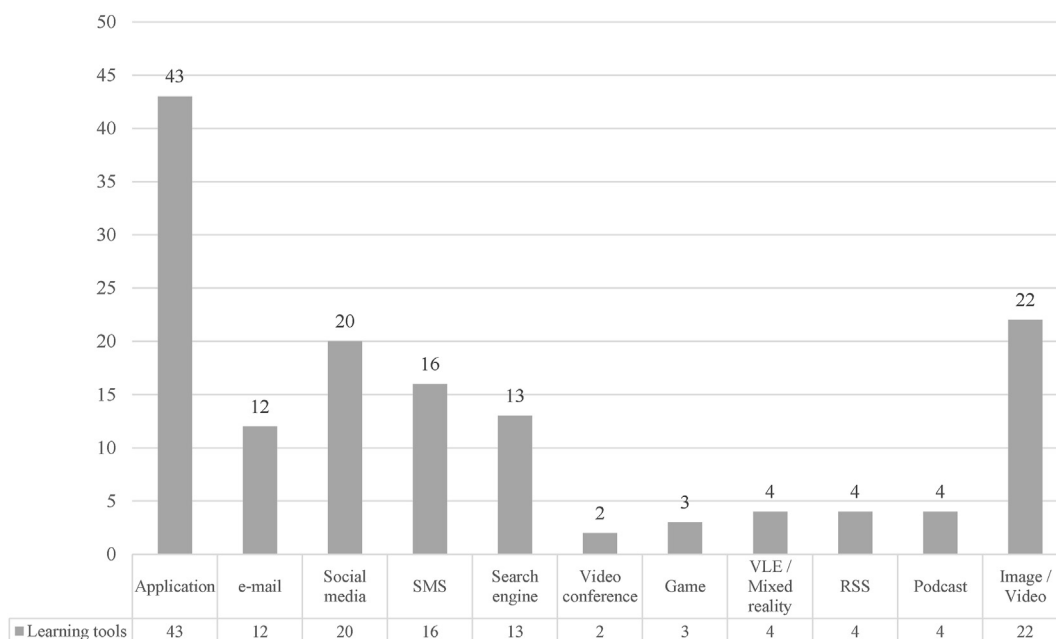


Figure 2. Learning tools.

As summarized in Figure 2, applications in mobile devices are the most commonly reported learning tools in mobile learning (Alioon and Delialioglu, 2015; Shorfuzzaman and Alhussein, 2016) of their diverse functionalities for learning activities (Felisoni and Godoi, 2018; Jarrahi et al., 2017; Sobaih et al., 2016). Furthermore, some instructors have developed custom-made mobile learning applications for their own courses (Parsazadeh et al., 2018). Nevertheless, other functionalities in mobile devices are also used as learning tools, such as images/videos (Gu et al., 2014; Leinonen et al., 2016), social media (Gikas and Grant, 2013; Lam and Duan, 2012; Masters et al., 2016; Nayak, 2018; Ooi et al., 2018; Oberer and Erkollar, 2013; Scott et al., 2017), SMS (Ekanayake and Wishart, 2015; Kuznekoff and Titsworth, 2013; Scott et al., 2017), games (Mu and Paparas 2015; Nayak, 2018), and virtual learning environments (VLE; Frank and Kapila, 2017) have been documented.

### 3.3. Learning activities

The reviewed studies suggest that learning performance and various skills might be improved by diverse instructional strategies, for example collaboration, group discussion, field trips, reflection, or inquiry-based learning (Figure 3). Discussion, collaboration, and feedback were the most commonly reported learning activities in mobile learning (Chang et al., 2016; Chuang, 2015; Lan et al., 2012; Masters et al., 2016; Pimmer et al., 2014; Seta et al., 2014; So, 2016). These learning activities can be integrated in courses using a variety of mobile applications. For instance, learners can take photos and share them through a messenger application, enabling their peers to discuss and share ideas about the shared images as well (Bellina and Missoni, 2011; Chang et al., 2016; Gedik et al., 2012; O'Bannon and Thomas, 2015; Pimmer et al., 2014; So, 2016). During field trips, learners can search online information while on site, share their experience immediately, record videos or images, and link their direct experience with online information (Al-Emran et al., 2016; Domingo and Garganté, 2016; Melero et al., 2015). To improve learning through direct experience, instructors can recommend learning resources, websites, or applications that learners can access easily by themselves (Herrington et al., 2009).

### 3.4. Barriers of mobile learning

In spite of the rapid pace of technological innovation, the available tools still pose barriers to mobile learning (Figure 4), key barriers can be categorized into three groups, which are 1) technology-related problems (Frank and Kapila, 2017; Jarrahi et al., 2017; Masters et al., 2016; Zhang et al., 2016), 2) basic skills in using mobile devices (Crane et al., 2011;

Jeno et al., 2017; Mori and Harada, 2010; Thomas and Fellowes, 2016), and 3) instructors' attitude towards applying mobile devices in education (Gikas and Grant, 2013; Pimmer et al., 2013).

The technology-related problems include factors like the stability of Internet connections, appropriateness of keyboard and screen size, and distractions during learning through mobile devices (Crane et al., 2011; Gu et al., 2011; Heflin et al., 2017; Jeno et al., 2017; Masters et al., 2016; Scott et al., 2017; So, 2016). Another challenge that learners face is the network security of free Wi-Fi in public places (Masters et al., 2016). Some learners mentioned problems related to the interface or general difficulties in using their devices (Frank and Kapila, 2017); others noted inconveniences caused by accessories, such as short battery life (Jarrahi et al., 2017; Masters et al., 2016). These problems may have to be solved to improve the applicability of devices or networks to mobile learning in the future.

Insufficient knowledge and skills in using mobile devices are crucial problems that obstruct learning experiences. Those skills include, for example, video recording, setting up the device (Mori and Harada, 2010), or installing and using applications in the mobile device (Thomas and Fellowes, 2016).

A number of instructors prefer face-to-face (F2F) sessions rather than online sessions (Christensen and Knezek, 2018); whereas some "anti-technology" instructors may discourage learners' use of mobile devices in class (Gikas and Grant, 2013).

### 3.5. Factors influencing mobile learning

The research so far has also described a variety of factors influencing mobile learning, as summarized in Figure 5. Because nearly everyone at present owns mobile devices, compatibility with such devices and attitudes towards them are key reasons why they are being used as learning tools. Thirty-one of the reviewed studies identified that compatibility was the key reason to use mobile devices in learning (Althunibat, 2015; Briz-Ponce et al., 2017; Fulantelli et al., 2015; Karimi, 2016; Kim et al., 2017; Koç et al., 2016; Oberer and Erkollar, 2013; Ooi et al., 2018; Parsazadeh et al., 2018; Shorfuzzaman and Alhussein, 2016; So, 2016). The attitudes of learners, instructors, and learners' parents was the second-most commonly reported factor affecting mobile learning (Briz-Ponce et al., 2017; Cho et al., 2017; Fulantelli et al., 2015; Jones et al., 2013; Molinillo et al., 2018; Reychev and Wu, 2016; Sánchez-Prieto et al., 2017; So, 2016). This factor might increase the role of mobile learning in various curricula, not only within the classroom but also outside.

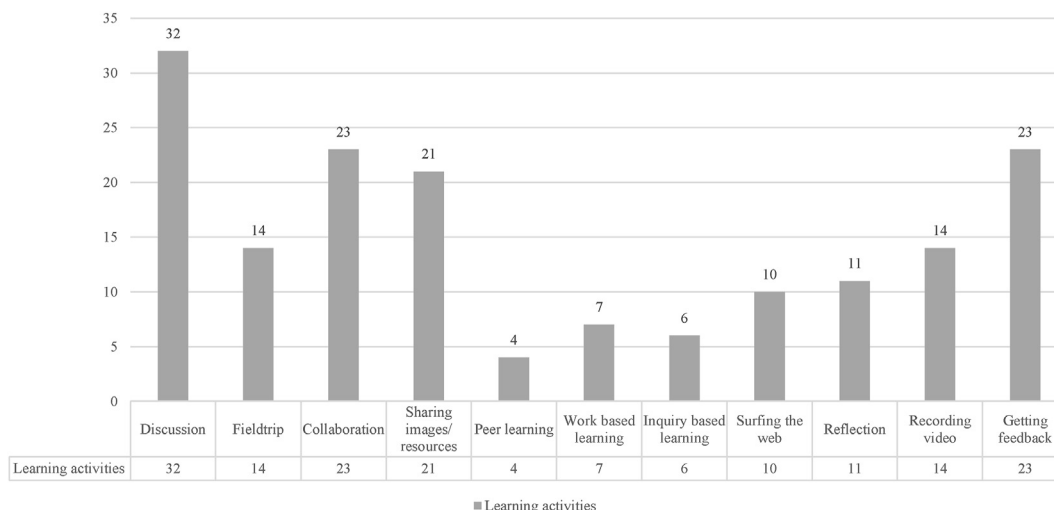


Figure 3. Learning activities in mobile learning.

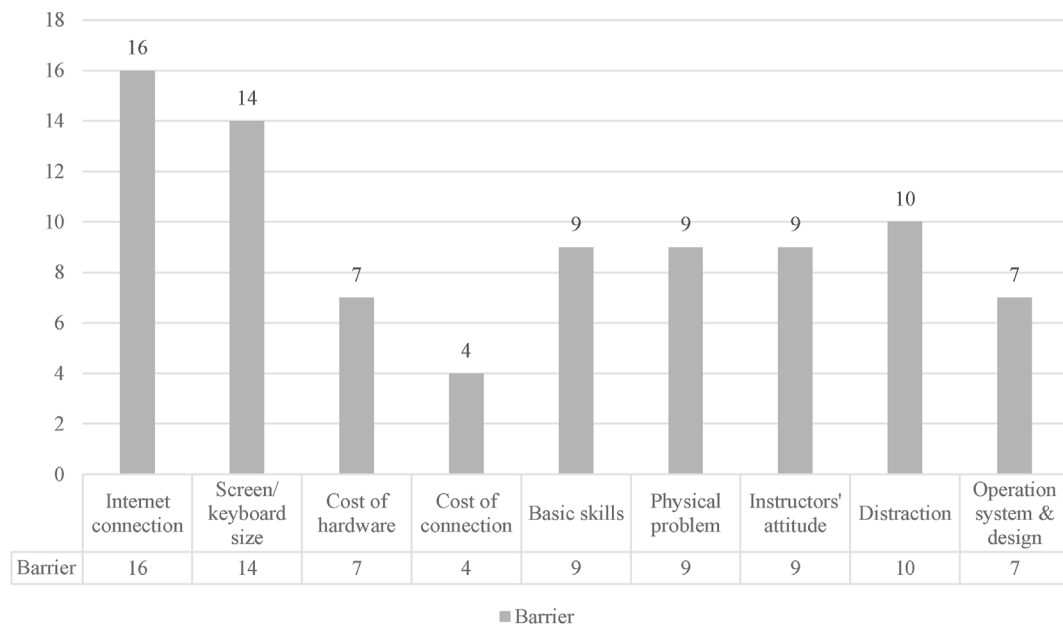


Figure 4. Barriers of mobile learning.

4. Discussion

The aim of this systematic review was to examine the features of mobile learning in higher education based on a content analysis of the 78 studies on mobile learning included in the review. The findings highlighted that mobile learning integrates online learning with learning in the offline world. Mobile learning as a concept is broader than learning using a mobile phone; any devices that can connect to the Internet and communicate with others can be used for it (Gikas and Grant, 2013). The functions of mobile devices also enable them to be used in special needs education, for example with learners who have autism or visual impairment (McQuiggan et al., 2015).

Mobile learning may be defined as learning that blends learning online with situated learning. Hence, mobile learning may happen in contexts such as museums, zoos, botanical gardens, or markets (Chang et al., 2011; Cheon et al., 2012; Domingo and Garganté, 2016). Mobile devices can also be used as tools for submitting homework, reflecting on immediate learning experiences, and for sharing ideas (Hou et al., 2014; Oberer and Erkollar, 2013; Wong et al., 2015). For these

reasons, mobile learning is a kind of personalized learning (Lam and Duan, 2012; McQuiggan et al., 2015; Nedungadi and Raman, 2012) that is affected by individual differences, topics of interest, and performance. Therefore, learners will determine their learning goals, choose learning content, and their own pace of learning when using mobile devices (Huang et al., 2012). Furthermore, learners can apply their networks on social media as their own learning community for sharing learning experiences (Gu et al., 2014) This kind of learning enhances learning by expanding the boundaries of where and when it can take place.

In addition to advantages of the devices, various creative learning strategies that instructors apply in their courses can enhance learners' self-directed learning by providing resources and productive strategies (Gu et al., 2014). Collaborative learning is the most popular learning strategy that instructors choose for mobile learning in their courses (Christensen and Knezek, 2018; Lackovic et al., 2017; Ooi et al., 2018; Seta et al., 2014) through online tools utilizing mobile devices, such as mobile applications, video conferences (Molinillo et al., 2018), and web applications (Parsazadeh et al., 2018).

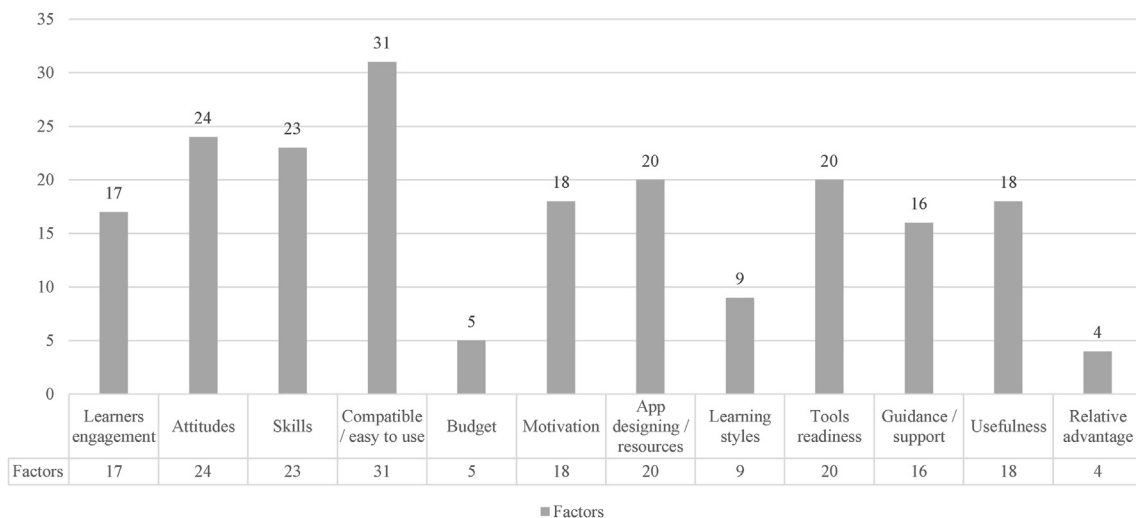


Figure 5. Factors influencing mobile learning.



Nevertheless, learners need some skills and knowledge for preparing learning through mobile devices (Briz-Ponce et al., 2017; Ekanayake and Wishart, 2015), especially in using applications in mobile devices and to maintain their cyber security (Jarrahi et al., 2017). Instructors also need computer skills for teaching (Cho et al., 2017) and techniques to apply mobile devices in traditional classrooms (Christensen and Knezek, 2018). However, skills and knowledge in using mobile devices are not the main challenge with mobile devices; the biggest one may be infrastructure, such as the Internet connection and limitations of the devices (Mu and Paparas, 2015; Nayak, 2018; Parsazadeh et al., 2018; Seta et al., 2014).

Although the cost of Internet connection and hardware have been reported to hamper mobile learning in higher education, this has not been the case for mobile knowledge workers (Jarrahi et al., 2017). Another challenge is that applications that instructors use as their learning platform for sharing experiences, homework, or other purposes are viewed as an entertainment tool rather than a learning tool (Lackovic et al., 2017).

Mobile learning is still challenged by barriers such as the low quality of devices, learners' acceptance, or Internet access (Al-Otaibi et al., 2016; Boulos et al., 2006; Cheon et al., 2012; Gikas and Grant, 2013; Koç et al., 2016; Lin and Lin, 2015; So, 2016; Witt et al., 2016). Instructors also need to consider factors such as learners', parents', and other instructors' attitudes toward mobile learning (Al-Emran et al., 2016; Briz-Ponce et al., 2017; Cheon et al., 2012; Jones et al., 2013; Karimi, 2016; Martí and Ferrer, 2012), learners' motivation (Pimmer et al., 2014; Shorfuzzaman and Alhusein, 2016; So, 2016), or learners' readiness (Althunibat, 2015; Lam and Duan, 2012; So, 2016; Witt et al., 2016).

Based on the features and other elements of mobile learning that were analyzed and synthesized in the literature review above, a graphical representation was created for summarizing features of mobile learning (Figure 6). Because mobile learning does not only involve using mobile devices for transmitting information to learners, instructors should consider learners' learning styles, attitudes, or readiness for acceptance of mobile learning. Hence, analyzing the content, tools, objectives, and learners should be central for identifying how to deliver content, arrange activities, and conduct assessment. The scope and kind of content should determine appropriate types of media for transferring information to learners, as well as the length of each module or lesson. Meanwhile,

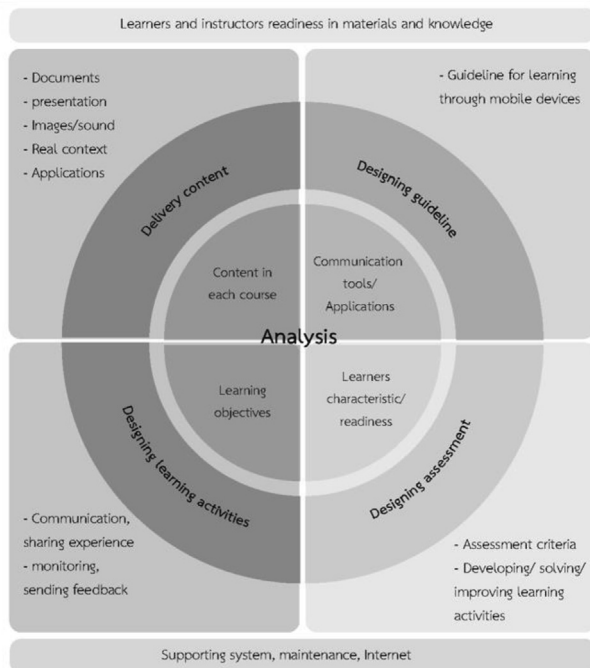


Figure 6. Features of mobile learning.

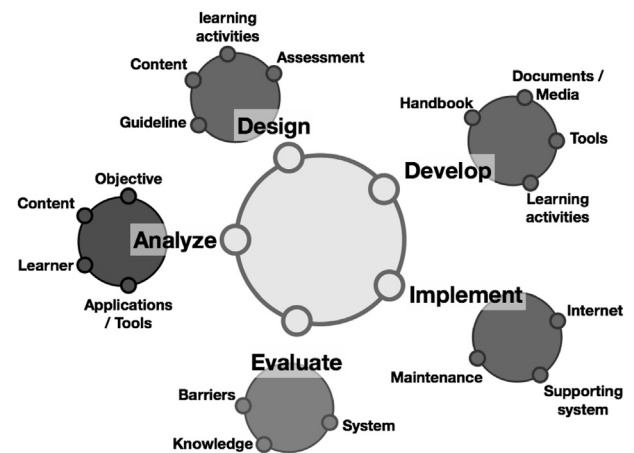


Figure 7. Instructional design for mobile learning.

learning objectives and learners' characteristics should be taken into account in determining learning activities and assessment strategies.

#### 4.1. Implications

In blended mobile learning, instructors should pay particular attention to instructional design, which includes objective identification, learner analysis, learning material design and development, and instructional evaluation (Benson Soong et al., 2001; Bjekić et al., 2010; Hrastinski, 2009; Marković and Jovanović, 2011; Priem et al., 2011; Rau et al., 2008; Song et al., 2004; Watkins, 2005; Yengin et al., 2010). Instructors can improve learning outside the classroom by encouraging online discussions on mobile devices using applications such as Facebook Messenger, LINE, Twitter, or others for increasing knowledge sharing and learning communication between learners (Benson Soong et al., 2001; Hrastinski, 2009; Marković and Jovanović, 2011; Rau et al., 2008; Wagner, 2008; Watkins, 2005).

Figure 7 summarizes the aspects of instructional design that instructional designers or instructors should examine when designing mobile learning: (1) the design of mobile learning courses should include analyzing learners' readiness, infrastructure, course contents, learning objectives, and the environment for creating appropriate learning activities; (2) learning activities should be organized consistently taking into account the learning context and content, and designed for improving learners' knowledge and enhancing their awareness on each topic; (3) instructors should consider the possible impact of the available Internet connection and the appropriateness of learning applications for activities. Moreover, instructors should consider and follow-up assigned activities in their chosen learning management system (LMS; Crompton and Traxler, 2018). Although mobile learning has many advantages in improving learning experiences, instructors should also take into account and manage the barriers of mobile learning described above.

#### 4.2. Limitations

This article reported a systematic review focusing on mobile learning in higher education and lifelong learning. Thus, it does not cover mobile learning in primary or secondary school contexts, and the features of mobile learning in other contexts may differ from those described in this review. This review was limited to studies published in English between 2006-2018 that were listed in the selected databases and covered the keywords "mobile learning" and "higher education." Therefore, some relevant studies may not have been included if they did not fit those criteria. In addition, due to the rapid pace of technological development, some elements in mobile learning, such as the learning tools, strategies, activities, or functions described above may quickly change or become

outdated in the near future, necessitating further research to document such changes.

#### 4.3. Future research

The systematic review reported in this article indicates that mobile devices not only facilitate learning in higher education; their use in informal and lifelong learning also require studies for identifying appropriate learning strategies and activities. The role of social media, which is currently affecting everyone, is another tool that should be examined further in mobile learning contexts. Past studies indicate that the interfaces of various applications and screen size of devices pose considerable challenges; future research should explore strategies to overcome these challenges.

#### Declarations

##### Author contribution statement

Samoeakan Sophonhiranrak: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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##### Data availability statement

Data included in article/supplementary material/referenced in article.

##### Declaration of interests statement

The authors declare no conflict of interest.

##### Additional information

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