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Mobile learning frameworks and pedagogy: A systematic review

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Abstract

This article provides a systematic review of mobile learning frameworks that address issues of pedagogy published between 2011 and 2022. The objective of the review was to gain a clear picture of recent developments in mobile learning frameworks to provide an understanding of current directions in mobile learning pedagogy. Eighteen peer-reviewed journal articles that presented new mobile learning pedagogical frameworks were examined and evaluated based on the characteristics of each framework. The two main areas of analysis were the pedagogical approaches integrated into the frameworks and their definitions of mobile learning. We conclude that mobile learning frameworks have become more diverse over time, in many cases tending to focus on specific aspects of mobile learning rather than attempting to address overarching concepts. With respect to pedagogies and their underlying theories of learning, social constructivism, heutagogy, collaborative learning, experiential learning, inquiry-based learning, and student-centred learning were mentioned most frequently. However, although many frameworks make reference to pedagogy, there is limited analysis of how mobile learning pedagogy might be defined as distinct from other contexts of learning. The key characteristics of mobile learning, consistent through most of the reviewed frameworks, comprise the portability of mobile devices across multiple contexts, connectivity, and accessibility, as well as learner-

centredness (including personalisation and self-regulation). One key aspect of identifying the uniqueness and future potential of mobile learning is the special affordances addressed by mobile learning theory. We conclude that this is an area where further research is required.

Introduction

Mobile learning as a research area originally came to prominence in the first decade of the 21st century. During that period, the major conferences and journals related to mobile learning were established, and literature began to appear that attempted to define what the concept of mobile learning could mean for researchers, practitioners and learners (Parsons, 2014). Part of this process was the development of several frameworks for mobile learning that addressed areas such as design, implementation, and evaluation.

Over time, interpretations of mobile learning have continued to evolve, mostly as a result of advances in technology. For example, in the early days of mobile learning research, mobile devices could be identified as discrete platforms for learning, whereas now they are integrated into much broader ecosystems of connected technologies (Palalas, 2013). Further, what could be classified as a mobile device has also evolved, as the Internet of Things increasingly encompasses multiple technologies that afford learner/learning mobility and may also be leveraged in the learning process (Kassab et al., 2020). This suggests that frameworks for mobile learning that were developed in the first ten years of significant mobile learning research may not perhaps fully address the potentials and affordances of mobile learning that are currently available. In addition, the blurring of the boundaries between mobile learning and other types of digital learning raises questions about the unique aspects of mobile learning that may still differentiate it from other types of learning supported by digital technologies. These questions stem from the shifting changes in the environment within which it takes place - influencing the unique characteristics, strategies, applications, and approaches that distinguish it from other forms of learning.

Within this broader contextual frame, this systematic review of recent mobile learning frameworks focuses in particular on pedagogy. It explores how the frameworks included in the review incorporate different pedagogies and their related theories of learning. In addition, it identifies the definitions of mobile learning that emerge from the selected articles and frameworks. From this, we gain an understanding of current research and practice in the field of mobile learning that raises some important questions about current views of pedagogy and practice.

The objective of the review

The objective of this systematic literature review is to analyse the extant literature on mobile learning frameworks that take account of pedagogy, published within the time frame 2011 to 2022 inclusive. The purpose of this review is to gain an understanding of what new frameworks have been developed during this period to identify any new contributions to our understanding of mobile learning that these frameworks may provide. Also, to consider what these frameworks contribute that can help us to understand the current consensus around the unique value proposition of mobile learning pedagogy.

Background

Before analysing the literature selected for this systematic review, it is necessary to briefly summarise some of the key ideas from the literature around mobile learning frameworks published prior to the period in question. A series of frameworks were published between 2007 and 2009, covering different aspects of mobile learning. Some of these were conceptual frameworks addressing high-level concepts seen to be important in mobile learning. Koole's

(2009) Framework for the Rational Analysis of Mobile Education (FRAME) model, for instance, bears some similarities to the TPACK model (Koehler & Mishra, 2009) in its approach of overlapping concepts. However, in this case the three concepts are not technology, pedagogy and content, but three aspects of mobile learning: device, social and learner. A similar framework, in terms of identifying and overlapping core concepts, is the socio-cultural framework of Pachler et al. (2009), which considered the structures, agency, and cultural practices of mobile learning.

FRAME and the socio-cultural framework may bear some resemblance to TPACK but were not directly derived from it. However, some mobile learning frameworks were strongly grounded in previous work that was not originally focused on mobile learning. Examples include those that were based on activity theory, situating it in the mobile learning space (Uden, 2007) or linking it to computer supported collaborative learning (Zurita & Nussbaum, 2007), whereas Laurillard (2007) also further developed her conversational framework to take account of the unique features of mobile learning.

These frameworks were largely conceptual. In contrast, Parsons et al. (2007) offered a design requirements framework for mobile learning, which focused on the environment, context, experience, and objectives. Passey (2009) offered a systemic implementation framework for mobile technologies that considered four parallel paths: learning activity, technical, political, and cultural. The intention of this framework was to provide overall guidelines that schools should consider for implementation. There was also a range of frameworks for evaluation of mobile learning that were proposed, including those from Traxler (2007), Motiwalla (2007), as well as Vavoula and Sharples (2009), each with somewhat different concerns and emphases. Thus, we can see a chain of frameworks constructing an emerging path through conceptualisation, design, implementation, and evaluation of mobile learning, prior to the period covered by this systematic review.

Prior reviews

There have been some previous reviews of mobile learning frameworks for various contexts. Koenraad (2019), introducing the iPAC framework (covered later in this article), included a review of frameworks in the area of Mobile Assisted Language Learning (MALL) and provided a broad discussion of activity design and evaluation frameworks in the MALL context. Hsu and Ching (2015) provided a review of 17 models and frameworks for designing mobile learning experiences and environments. This differed from the current study in including both models and frameworks, and not focusing specifically on pedagogy. Their analysis divided the models and frameworks into the following categories: pedagogies and learning environment design, platform/system design, technology acceptance, evaluation, and psychological construct. They concluded their review by suggesting that areas where further work was needed were frameworks for game-based augmented reality, mobile learning in developing countries, and unifying the various studies that addressed different factors in mobile learning technology adoption. The articles selected were published between 2006 and 2013 and were sourced from a different set of databases from that used in the current study. We therefore regard the Hsu and Ching article as a complementary precursor to the current study, which is more future focused and emphasises pedagogical aspects of mobile learning.

A more recent study that can help us to frame mobile learning within a contemporary context is the one reported by Hall et al. (2020); it aligns mobile learning design principles with the move to online learning during the COVID-19 pandemic and provides a review of country-based responses. The article outlines 21 design principles underpinning innovative mobile learning, which emerged in the context of the three-year European Designing and Evaluating Innovative Mobile Pedagogies (DEIMP) Project (2017-2020). The key areas for development are stated as adaptivity, authenticity, collaboration, mobility and student choice. The framework referred to in this study is included in one of the selected articles for the review, discussed later (Kearney et al., 2012).

Against this background, the study reported in this article seeks to explore how mobile learning frameworks have addressed aspects of pedagogy over the years 2011 to 2022. In doing so it compares the themes of recent frameworks to those previously published and seeks to identify meaningful interpretations of what a mobile learning pedagogy looks like in the 2020s.

Methods

We used the PRISMA guidelines to structure this systematic review (Page et al., 2021). However, not all components of PRISMA apply in this case, which is not a medical study and is not primarily focused on quantitative data.

As discussed in the previous sections, the motivation for this study was to examine mobile learning frameworks that explicitly address pedagogy, and to identify how those pedagogies can help to define the unique properties of contemporary mobile learning. Our main research question for this study was:

- What are the key features of mobile learning frameworks that address pedagogy that can be found in the literature between 2011 and 2022?

  This is supported by two sub-questions, namely

- What kind of pedagogies and learning theories have been addressed in the identified mobile learning frameworks?

- What are the common themes of contemporary mobile learning that emerge from the identified mobile learning frameworks?

Search process

The following search terms were used to undertake database searches: ("Mobile learning" OR mlearning OR m-learning) AND (framework AND pedagogy). Searches were narrowed to receive results from abstracts and titles of peer-reviewed journal articles only. The time period was limited to twelve years, from 2011 – 2022 inclusive. Searches were performed through the following aggregated databases: EBSCO Discovery Services, Emerald Insight, IEEE Xplore, ProQuest, and Scopus. In total, 231 relevant articles were found.

These results (titles and abstracts) were then uploaded via EndNote to the Rayyan systematic review web-tool (Ouzzani et al., 2016) for screening, and decision-making related to exclusions and selections for the next stage of the process. The Rayyan software facilitated remote online collaboration among the team members of this systematic review. All team members fully participated in the process of screening, selecting and excluding.

The first task within the Rayyan software was to account for duplicates. 51 duplicates were identified, leading to a reduction in the number of articles for initial review to 180. These were then reviewed by the team members against the exclusion criteria. Articles were excluded if they (1) used a framework but did not propose one, (2) did not explicitly link the framework to pedagogy (3) did not include pedagogy in the discussion, or (4) were not from peer reviewed journals (some databases returned false positives).

All 180 abstracts were reviewed by at least two members of the team. 159 were reviewed by at least three members and 49 were reviewed by the whole team. At the end of this process there were 22 conflicts, with an inter-rater reliability of 87%. These were resolved through further discussion within the team. Through this collaborative process, 40 articles were accepted for further review, while 140 articles were excluded. At this point, full text articles were sought for the 40 selected articles. Two could not be sourced and were therefore excluded from the study, leaving 38 articles. The full text of each of these 38 articles was then scanned by at least two members of the team, with each member examining 20 articles each.

At the end of this process, 26 articles were chosen for a deeper review, while 12 were rejected. Included in this number were articles that were themselves systematic reviews. These were excluded from the review itself but potentially relevant to the discussion. There were five of these articles, some of which have been referenced in the introduction section. Other reasons for rejecting articles included the lack of a detailed framework, or discussing a framework that was not specific to mobile learning, or not linked to pedagogy, or did not originate from that publication. One additional article was selected to be included in the review, based on the level of citation among other articles being evaluated.

For the deeper review of the 27 candidate articles (26 plus the additional article) identified from the previous step, a shared spreadsheet was used to collate data and for collaborative decision-making. For this review, articles were examined against the following criteria, and notes were taken regarding: (1) the identification of the framework within the article, its purpose, and confirmation that this was its first introduction, (2) the contextual use of the framework (actual or proposed), (3) the pedagogical aim of the framework, (4) any unique aspects of mobile learning being addressed, (5) the type of study, and (6) the methodological approach to the study.

Eighteen (18) articles were eventually chosen for the systematic review, while nine were rejected. Eight of the rejected articles utilised frameworks that were already included among those chosen, while another article was about a measure linked to a framework but not the framework itself.

Figure 1 summarises the results of the search and selection process using a PRISMA flowchart.

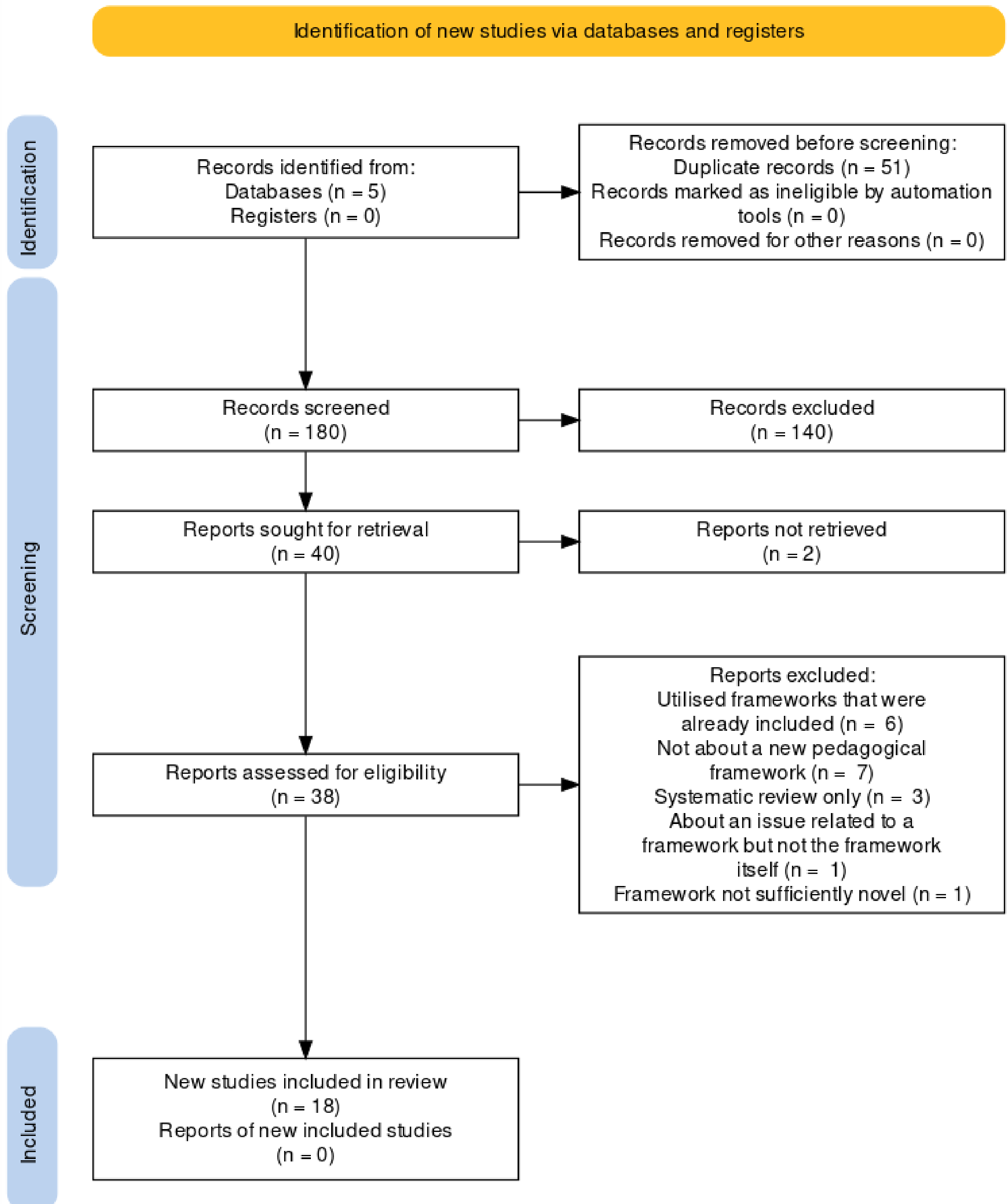

Fig. 1: The study selection process

Summary of the Selected Studies

In this section, we outline the general characteristics of each included study. Table 1 summarises the main details of the studies, including the author(s), year, title, name, and brief description of the framework, as well as the aspects of pedagogy addressed. The publication years of the selected articles (Table 1) were quite evenly spread over an eleven-year time period, with publications from 2011, 2012, 2013 (4), 2014 (2), 2015, 2016 (3), 2017 (2), 2019 and 2021 (3). Although some articles from 2022 were assessed, none were found suitable for the final selection.

Regarding the education level for which the framework is intended, half of the reviewed studies do not specify the level (50%) while one-third of the studies (31%) focus on the undergraduate level (Fig. 2).

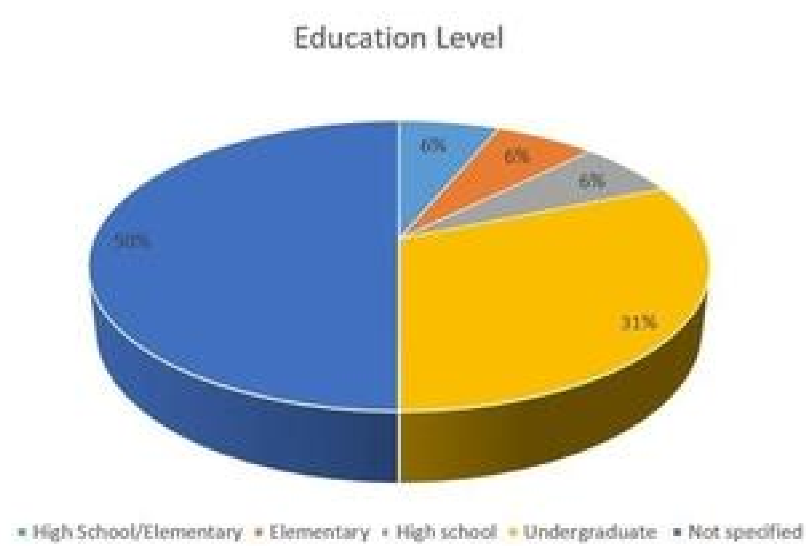

Fig 2: Intended educational level of the frameworks selected for review

Regarding the underlying learning theories or pedagogies of the studies under review, five studies (27.8%) reported social constructivism as the learning theory of choice, three studies (16.7%) collaborative learning, two studies (11.1%) student-centered pedagogies, two studies (11.1%) participatory simulation, one study (5.6%) heutagogy, and one study (5.6%) inquiry-based learning. One study (5.6%) reported more than one underlying pedagogy, while three studies (16.7%) did not identify any specific underlying learning theory or pedagogy (Fig. 3). It should be noted that the studies tended not to explicitly separate out the intended learning process (theories of learning) from the teaching process (method of pedagogy). Therefore, by "social constructivism", for instance, we assume a pedagogy that enables students to construct their own learning while working collaboratively.

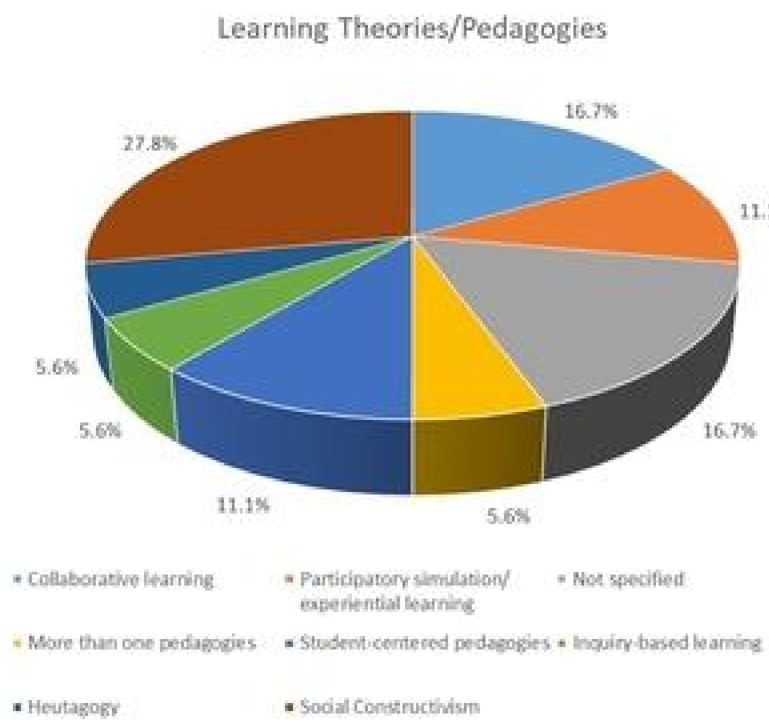

Fig 3: Underlying learning theory or pedagogy of the frameworks selected for review

Only eight of the studies have their proposed frameworks evaluated by learning activities, and just four of them reported the subject area their framework was developed for, or to which it could be applied. Ten of the studies defined mobile learning by either using an existing definition or introducing a new one. Twelve of the studies emphasised specific aspects of mobile learning in their proposed framework.

Framework areas of focus

As noted in the introduction, frameworks published in the years prior to the timeframe of the current study tend to fall somewhere in the chain of conceptualisation, design, implementation, and evaluation. The frameworks analysed in the current study do not fit into this set of categories, apart from some that focus on design (Al-Hunaiyyan et al., 2017; Dennen & Hao, 2014; Park, 2011; Shamsuddin et al., 2016), and one that focuses on implementation (Tan et al., 2016). The other frameworks address various other aspects of mobile learning such as inquiry-based learning (Buckner & Kim, 2014; Nikou & Economides, 2021), mobile virtual reality (Cochrane, 2016), social media (Cochrane & Rhodes, 2013), teacher-centred technology integration (Crompton, 2017), situated and context-based learning (Khaddage et al., 2015), linking formal and informal learning (Lai et al, 2013), the context of low- and middle-income countries (Okai-Ugbaje, 2021), institutional or strategic management (Ng & Nicholas, 2013; Moya & Camacho, 2021), sustainable mobile learning (Ng & Nicholas, 2013; Moya & Camacho, 2021), participatory simulation (Yin et al., 2013) and collaborative learning (Zidoun et al., 2019), also linked with authenticity and personalisation (Kearney et al., 2012). It might be said that many of these frameworks have a very narrow focus, either on specific applications of mobile learning, or individual technologies. This would suggest that, unlike the types of frameworks being developed prior to 2011, these frameworks are not particularly generalisable.

Apart from making them hard to reuse across settings, they do not help to distil any universal characteristics that would define mobile learning in the contemporary context.

To distinguish the unique aspects of contemporary mobile learning and its associated pedagogies implicit in the reviewed frameworks, we have identified the key common themes and constructs across these frameworks. These are addressed in the following discussion section.

Discussion

The articles selected for this systematic review address different aspects of mobile learning frameworks. They use different representations, focus on various disparate and specific areas of mobile learning, and in some cases (but not all) include some empirical evidence that supports the design of the proposed frameworks. Notwithstanding this diversity of frameworks, several important themes and questions emerge from the selected literature. One of the key foci of the review was that it aims to identify and explore mobile learning frameworks that address pedagogy, and this is one area that we examine in this section. There is also a broader context within which these articles define or explain mobile learning. This is an important question, as different conceptions of what mobile learning may be are impacted by technological change and new ways of learning in the broader space of digital mobilities. Different audiences are also important here, since the target audience of a mobile learning experience (e.g., learners from low- and middle-income countries, or schoolchildren) may impact the nature of the proposed framework. In addition, some articles do not focus particularly on mobile learning itself but on related aspects such as leadership and management, for example, Moya and Camacho (2021) explicitly adapt a framework from strategic management. This of course changes how we might use and interpret the frameworks discussed. We may need to question what comprises a mobile learning framework if its main concern is, in fact, a concept only loosely associated with mobile learning. This also applies where a learning experience that informs the design of a framework uses mobile tools but could equally be achieved without concepts of mobility.

Pedagogies (and learning theories) in the selected frameworks

As aptly observed by Zidoun et al. (2019), mobile learning research has often been centered around the technical aspects of mobile tools and applications and less on the pedagogical aspect and learning approaches. In analysing the various references to mobile learning pedagogy in the selected articles, there are a few common themes that emerge. Opportunities for collaborative learning certainly come to the fore, addressed by Buckner and Kim (2014), Kearney et al. (2012), Lai et al. (2013), Moya and Camacho (2021), Nikou and Economides (2021), Okai-Ugbaje (2021), and Tan et al. (2016). Social constructivism, which also relies on collaboration but is defined somewhat more narrowly in terms of learning theory, is also referenced by several frameworks, namely Cochrane (2016), Cochrane and Rhodes (2013), Dennen and Hao (2014), Okai-Ugbaje (2021), and Tan et al. (2016). In a similar vein, Yin et al. (2013) refer to constructivist participatory simulations.

Inquiry or problem-based learning appears in Buckner and Kim (2014), and Lai et al. (2013), while situated, context- or location- based learning, which also aims at engaging students with real-world tasks, is mentioned by Cochrane (2016), Khaddage et al. (2015), Nikou and Economides (2021), and Tan et al. (2016). Related to these pedagogical concepts of learning by interacting with a task and/or an environment, constructivist-based experiential learning (applying participatory simulations) is addressed in Yin et al. (2013), and authentic learning by Kearney et al. (2012).

The learning approaches mentioned above are dependent on learners being given a suitable degree of agency and autonomy over their learning. This is explicitly addressed by

Khaddage et al. (2015) and Park (2011) but is implicit in many of the other frameworks which are intrinsically student-centered in their approach to pedagogy. Related to this focus on the student's perspective, personalisation of learning also appears in several frameworks, namely Kearney et al. (2012), Moya and Camacho (2021), Tan et al. (2016), Nikou and Economides (2021), and Zidoun et al. (2019).

These common themes concerning pedagogical constructs point to a shared view of mobile learning pedagogy. However, it should be noted that not all the analysed frameworks align well with this view. Some address pedagogical approaches that would seem at odds with this apparent consensus, for example, the focus on rote learning in Shamsuddin et al. (2016). Other frameworks stress the importance of pedagogy in mobile learning without necessarily specifying what that pedagogy might look like. For example, Crompton (2017) focuses only on the teachers' integration of mobile technologies into their practice, while Ng and Nicholas (2013) take an administrative perspective. The remaining frameworks focus on designing learning systems rather than addressing the pedagogies that support them in any detail (e.g., Dennen & Hao, 2014; Park, 2011).

More concerning, perhaps, is that even in those frameworks that do address pedagogy explicitly, there is little in-depth discussion of why those pedagogies have been selected, or how they actually play out in practice. In addition, the distinction between learning theory and pedagogy is not always clearly made in the articles. There is often a rather loose tendency to equate a learning theory with a pedagogy without further explanation. Social constructivism, for example, is a learning theory, not a pedagogy; there needs to be some clear understanding in a mobile learning framework that claims to address pedagogy, how the theory informs the pedagogy, and why it is suited to mobile learning. Some of the articles reviewed herein appear to assume that the reader already understands how, for example, social constructivism would inform the pedagogy in a mobile learning environment. This seems unlikely, in fact, since mobile learning mediates any pedagogy in specific ways that may render it qualitatively different from the same pedagogical approach used in another context. For example, collaborative learning in a mobile context may include learners collaborating remotely from different and changing locations. Mobile inquiry-based learning may involve students taking data from the environment using mobile devices, and collaboratively analysing that data. As another example, personalisation in mobile learning may be more specific to the learner's context and personal device than it is in other scenarios.

This lack of explanation in some articles about what the authors mean by a theory/pedagogy makes it harder to see how these concepts may be operationalised through their proposed frameworks. For example, Dennen and Hao's M-COPE framework (2014) refers to pedagogy, and highlights social constructivism as a relevant theory, but does not give any detail on pedagogical practice within the framework. Similarly, Okai-Ugbaje (2021) outlines a framework that states a pedagogy based on a combination of social constructivism and flow theory. Unfortunately, the article does not explain how these theories are combined into a pedagogy that can be supported by the framework. However, in a follow-up article in 2022, there is a further exposition of these themes, and how applying these theories may bridge the cultural power distance between instructors and learners (Okai-Ugbaje et al., 2022). An important question is whether mobile learning pedagogy can be seen as distinct from other pedagogies. To what extent is each article specifically addressing mobile pedagogy as opposed to broader digital pedagogy? While it is evident that mobile devices can assist traditional pedagogies, such as teaching practices informed by social constructivism, or shifting the focus from teacher-centred to student-centred learning, the question behind these uses of mobile devices in learning is whether there is an identifiable mobile learning pedagogy that is novel and distinct.

One way of addressing this question is to consider how pedagogies may be mediated through mobile technologies. For example, if active discovery learning takes place through the use of mobile technologies, a particular type of mobile learning pedagogy is required that differs from other active learning approaches. Buckner and Kim's SMILE framework (2014) focuses on the pedagogy of inquiry-based learning, specifically assisted by mobile devices. According to the authors, mobile devices have several advantages over computers (e.g., require less infrastructure, educational content is available through apps, and they are ubiquitous) and can be successfully utilised to promote inquiry-based learning in a variety of contexts, inside and outside the classroom, and in diverse contexts including those in the developing world. This view of mobile learning pedagogy does recognise the unique affordances of mobile devices for learning. The Mobile-Blended Collaborative Learning model (Lai et al., 2013) also encourages inquiry- and problem-based learning and provides a framework whereby mobile technologies provide a bridge between the pedagogies of formal (in-class) and informal (community-based) learning. The "on-demand" capability of mobile technology supports the collaboration, coordination, and communication activities of student-centered learning.

Pedagogies that foster collaborative learning appear in several frameworks. The five axes m-learning integration framework promotes "collaborative learning by offering more flexibility and personalisation of learning and allowing it to be more student-centred" (Zidoun et al., 2019, p. 167). The authors proposed this framework to guide educators in considering every aspect of mobile learning systems integration, including the pedagogy (method), content, mobile technology, learning environment, and learner's profile. They emphasise the pedagogy, "the teaching method is the starting point of this 5 axes mlearning integration framework" (p. 157), and it influences all the other factors, for instance, collaborative learning, problem-based learning, or experiential learning do not fit all content or learner profiles. The authors observe that the use of mobile devices should not be the main purpose of mobile learning but rather "it should be a good tool for making it work" (p. 159). They further comment on the importance of mobile learning context being used to optimise learning, including collaborative, authentic, and personalised learning. Both collaboration and personalisation, along with authenticity, are highlighted by Kearney et al. (2012) and Nikou and Economides (2021), with authenticity also mentioned by Moya and Camacho (2021). Different mobile learning scenarios from the mobile learning literature have been analysed through the lens of Zidoun et al.'s proposed framework. The authors claimed that the proposed framework turned out to be suitable to explore and critique the pedagogical impact of mobile learning.

In addition to supporting collaboration, mobile learning also emphasises individualised learning using personal mobile devices. Park (2011) addresses these two aspects of learning within a framework that recognises the importance of both communication and learner autonomy. Individualised learning is also highlighted in the 5R Adaptation Framework (Tan et al., 2016), which takes account of the learner's learning profile and learning styles. Autonomy, along with relatedness and competence, is also discussed in the framework proposed by Nikou and Economides (2021). This framework is based on the self-determination theory of motivation and proposes various pedagogies (e.g., collaborative learning, situated and authentic learning, problem-based learning) and how these can be supported by specific affordances of mobile technologies (e.g., context awareness, personalization, and adaptation, etc.) in order to enhance student motivation.

These examples suggest that mobile learning pedagogy provides a significant "value-added" element to enhance traditional pedagogies. However, for pedagogies to be transformed and enhanced through mobile learning there are many requirements that need to be met, including teachers knowing how to use the devices for mobile learning in an effective way (Khaddage et al., 2015). Teachers need to be familiar with device affordances, available mobile applications, and how to integrate these into their teaching (Ng & Nicholas, 2013). From the frameworks investigated here, it would appear that this can only be achieved if there is greater clarity about how mobile learning offers unique interpretations of more general learning theories and pedagogies, so that educators can be better informed about the special pedagogical opportunities offered by mobile devices.

Common themes of contemporary mobile learning

In the same way that some articles mention pedagogy without defining it, they leave the definition of mobile learning unspecified as well. It may be the case that the authors believe the term needs no further definition, having been extensively discussed in the past. However, since each framework has its own particular focus, a working definition of mobile learning for each specific framework would have been helpful.

Most mobile learning definitions present in the literature consider mobile learning as "the learning process mediated by a mobile device" (Zidoun et al., 2019). This common theme came up consistently in the reviewed studies. Mobile learning is an "anywhere and anytime" approach to learning using mobile technologies (Zidoun et al., 2019). Most authors, as expected, highlighted the portability of mobile devices (e.g., Crompton, 2017). Ng and Nicholas (2013) emphasise the just-in-time nature of mobile learning, while Park (2011) stresses learning across multiple contexts.

Accessibility is another important feature that has been highlighted in most studies under investigation. It is worth highlighting also that the broad availability of mobile applications for different purposes (Lai et al., 2013) makes mobile learning popular. Mobile devices are widely available and accessible even in disadvantaged areas or school settings (Buckner & Kim, 2014). Wireless connectivity is also identified as a key enabler (and feature) of mobile learning (Park, 2011; Yin et al., 2013). Assuming that appropriate wireless infrastructure exists, students can access educational materials anytime from any location (Al-Hunaiyyan et al., 2017; Khaddage et al., 2015).

Another theme that emerges from a number of the frameworks is that mobile learning is intrinsically learner-centred. This learner-centeredness is related to the nature of mobile devices, which are usually personally owned, and to the agency and control that learners have over the materials and tools that they choose to interact with (Khaddage et al., 2015). The learning experience can be highly personalised by the learners themselves (Kearnery et al., 2012; Nikou & Economides, 2021) so that the learning feels "just for me" (Park, 2011, p. 80). The flexibility of learning with a mobile device also contributes to personalisation, giving learners more choice (Zidoun et al., 2019), where learning can take place on demand (Lai et al., 2013). However, personalisation can also occur through the mobile learning system itself, by tailoring content to the profile of the learner (Tan et al., 2016), thus mobile learning is about both tailoring for the learner, and by the learner.

Mobile devices can support a learner's journey toward self-regulated learning. This aspect of self-regulation may relate to how students move across the spectrum of pedagogy - andragogy - heutagogy. Cochrane and Rhodes (2013) depict this transition from teacher-directed to learner-regulated social constructivist pedagogy in their study of a mobile social media framework for pedagogical transformation; they discuss a mobile learning pedagogical shift from pedagogy towards heutagogy. This journey resonates with the ability of mobile learning to act as a bridge between formal to informal learning (Lai et al., 2013). Moreover, as Nikou and Economides (2021) have addressed, when features of mobile learning are employed appropriately, they can support the basic psychological needs of autonomy, competence, and relatedness, making learning more motivating. Social network connectivity is another important feature of mobile learning because it provides technology-mediated communication and collaboration that promotes the social dimension of learning (Al-Hunaiyyan et al., 2017; Park, 2011; Nikou & Economides, 2021). The use of mobile social media is merely one aspect of the debate around the importance of the mobile component to the success of social media based learning. In what types of learning situations is social media intrinsically mobile? Or, is it just a convenient option to use a mobile device? One important factor here that may be a distinguishing feature of mobile learning is student-centeredness through their use of an individual device, which provides their own personal learning space and ownership of their own learning. Park (2011) discusses an adaptation to the transactional distance theory and how this influences the learner as an individual or group (individualised or socialised learning).

Educational resources accessible through mobile devices can have multiple digital formats (text, images, audio, video) facilitating higher levels of interactivity (Buckner & Kim, 2014) and student generated content (Cochrane & Rhodes, 2013; Nikou & Economides, 2021). Moreover, mobile devices can enable more immersive learning experiences through augmented reality (AR) or virtual reality (VR) technologies (Cochrane, 2016). AR and VR have the potential to offer motivating learning experiences and improved learning outcomes (Akçayır & Akçayır, 2017). Yin et al. (2013), with their scaffolding participatory simulation for mobile learning framework, used mobile AR and simulations to support conceptual knowledge learning. This context-aware participatory simulation framework was “designed to facilitate students’ experiential learning in either complex social contexts or face-to-face classrooms” (Yin et al., 2013, p. 140). Cochrane et al. (2016), in their study, further explored the potential of using mobile VR for designing learning experiences using network-centered pedagogies. The implementation of their framework provided some preliminary evidence that mobile-based immersive experiences can enhance learning.

From these various sources, we see that mobile learning has been defined as being accessible across times and contexts, learner-centred and personalised, collaborative and self-regulated, bridging formal and informal learning, and leveraging multiple digital media and technologies. However, many of these characteristics can be seen in the broader scope of digital learning. Therefore, a more specific definition of mobile learning is required. The four co-authors of the article came into this study with diverse, and even opposing, definitions of what constitutes mobile learning. As a result of the literature review and discussions of its findings, we agreed to a definition and submit that mobile learning is the unique learning experiences that are made possible by the mobility, interaction, and activities enabled by the affordances of mobile technologies embodied in both devices and infrastructure. We also asked questions about the role of contemporary learning theories in helping us to define mobile learning as a unique experience, which is briefly discussed in the following section.

What value does mobility add to learning?

One key aspect of identifying the uniqueness of mobile learning within the broader frame of digitally supported learning is the nature of the theories that underlie it. There have been several learning theories put forward in the 21st century that acknowledge the impact of digital technologies on learning. These include connectivism, collaborativism (also known as online collaborative learning), generativism, and dialogic education, among others. Connectivism suggests that our behaviour is being shaped through the use of technology, with an increasing emphasis on knowing where to find knowledge rather than the fixed acquisition of knowledge needed in the past (Siemens, 2005). Generativism aims at describing collaborative learning with digital technologies, and open educational resources and practices (Carneiro, 2011). In collaborativist learning, students are encouraged and supported to work together to create knowledge: to invent, innovate, and seek the information required to problem-solve, rather than simply seek a “correct” answer (Harasim, 2017). Dialogic education is about drawing students into participating in dialogues in unbounded contexts (Wegerif, 2013).

These theories recognise that the process of knowledge acquisition today is different to what it was before the Web and ubiquitous digital devices, and that the type of knowledge that is important has changed from recall (from memory) to retrieval (from external sources), so the learner is required to prioritise, filter and critique these sources to construct their own learning. They also recognise that learning is increasingly socially constructed across potentially global networks. However, these theories are limited in their inclusion of the implications of mobility. In contrast, mobile learning theory is based on the mobility of the learner, with learning interwoven with other activities as part of everyday life. Mobile learning can be formal or informal, distributed across, and interacting with, other learners, guides, resources and contexts (Sharples, Taylor, & Vavoula, 2005). These themes are reinforced by the research concept of mobilities, which emphasises alternative spaces of education and student mobilities (Waters, 2017). With the added context of mobility, we have more control over our own learning, the distinctions between formal and informal learning become blurred, and learning can take place beyond traditional boundaries of space, time, age, and wealth. Given these theoretical advantages, mobile learning should be at the forefront of current educational practice. Some of the frameworks we have examined have reinforced this message, but as can be seen by the summaries above, consistent messaging about the unique affordances of mobile learning is somewhat lacking.

Summary and Conclusions

The research questions for this study aimed to identify from the recent literature the key features of mobile learning frameworks that address pedagogy, to look at what pedagogies and learning theories these frameworks address, and identify any common themes of contemporary mobile learning that have emerged.

To address these questions, the systematic review reported in this article included 18 frameworks for mobile learning that addressed pedagogical issues. The results of this review suggest that, while various learning theories and pedagogies have been employed within these frameworks, there is no evidence of any distinct pedagogical method that is particularly associated with using mobile technologies for learning. Mobile learning activities can draw on behaviourist, constructivist, or social learning. They can also support different pedagogical practices, such as active learning, authentic learning, inquiry-based learning, and bridging formal and informal educational settings. This is in line with previous literature review studies (e.g., Crompton et al., 2017). The degree of innovation in the design and implementation of mobile learning activities, as seen through the lens of these frameworks, is not very high, which again agrees with other literature review studies (e.g., Burden et al., 2019). Even though the benefits that mobile technologies can offer in the learning procedure are significant (Sung et al., 2016), based on a review by Crompton and Burke (2020), mobile devices are very often used mainly to substitute or just augment learning activities without really modifying or redefining learning. Our study shows that numerous frameworks have been proposed to address the development of pedagogically sound mobile learning activities, but with few exceptions (e.g., the iPAC framework), these frameworks are conceptual rather than procedural, providing little guidance and support to teachers on how to implement effective mobile learning activities. It is interesting that many frameworks highlight the positive impact of using mobile devices on student self-regulation (Cochrane & Rhodes, 2013) or self-determination (Nikou & Economides, 2021). The latter is an attempt to align specific mobile device features (such as context-awareness and adaptivity, or social media connectivity) with the autonomy, competence and relatedness dimensions of the self-determination theory and different pedagogical practices (such as authentic and collaborative learning).

Given that mobile learning is founded upon the affordances of mobile technologies, it would be interesting to see the development of mobile learning frameworks that focus on the utilisation of recent technology developments such as LIDAR, 5G networks, and wearables.

It should be noted that during the process of the review we were aware that much literature was being generated about the impacts of COVID-19 and the role of mobile learning. Unfortunately, most of the work published thus far on mobile learning frameworks in a pandemic context simply revisits well-worn issues around intention to use (e.g., Sitar-Tăut, 2021, among many), and rarely addresses the specifics of mobile learning from a pedagogical perspective. Even the few articles that appear to address aspects of mobile pedagogy such as collaborative learning (e.g., Alismaiel et al., 2022) typically fail to make a clear distinction between online and mobile learning in the broader scope of pandemic-era emergency remote teaching or treat pedagogy as a very minor component of slightly modified acceptance models (e.g., Yuan et al., 2021). It is to be hoped that more insightful literature on the role of mobile learning pedagogy during the pandemic may yet emerge.

Limitations of this study

There are a few limitations to the evidence included in this review. The search for articles published during the period 2011-2022 is not exhaustive. Selected databases have been utilised. Furthermore, some of the articles provide insufficient and sometimes fragmented evidence related to the pedagogical aspects of their frameworks. Some of these frameworks are only proposals, lacking efficacy testing. For a few of the reviewed articles, the methodological approaches are not clearly defined, thus negatively impacting the authority of some of the evidence presented in the review.

The reported studies were conducted in formal education contexts, with each framework presented in a unique setting, with only a few disciplines represented, hence limiting the transferability of the findings. Most of the studies found were case studies with few experimental research studies, which did not allow us to draw generalisable conclusions about the effectiveness of the explored frameworks. The number of articles studied was limited as we included only publications that proposed a new framework and explicitly addressed aspects of pedagogy; for frameworks that were discussed in more than one peer-reviewed article, we selected the one publication that presented the framework most effectively. The authors' reliance on English language publications can be considered yet another limitation. These limitations do not alter the key outcome of the review, however, which is to suggest that mobile learning frameworks published during the period in question have not provided us with any significant new insights into mobile learning pedagogy or definitions, either from a theoretical or a practical level.

Implications for practice, policy, and future research

It is now more than 20 years since mobile learning emerged as a distinct area of research and practice, and over this time mobile technologies have evolved considerably. As a result, the way that mobile learning is perceived by researchers and practitioners has also changed dramatically. While mobile devices themselves have exponentially increased in terms of their ubiquity, functionality, and affordances, it is also the case that their role within a technology-enhanced learning infrastructure has also developed in ways that allow them to be used in a much more integrated way alongside other digital tools. We now see mobile learning being linked closely to broader concepts such as seamless learning. Further, the types of devices that might be considered as contributing to mobile learning have also proliferated with the Internet of Things, such that early concerns around what an individual user might do with an individual device have been supplanted by concerns about how dynamic groups of learners might operate with integrated networks of devices. Within this network, the learner's mobility is supported by a complex infrastructure that may comprise many devices.

The implications of this review are as follows. First, it suggests that the focus of mobile learning research has evolved into new, more specific areas over the last decade or so. Rather than concerning itself with a design, implementation, and evaluation process for mobile learning applications, it has attempted to more explicitly explore what types of learning might take place in different mobile learning contexts. It is notable that these contexts seem somewhat fragmented from the articles studied. This may indicate that we need to revisit our definitions of mobile learning to be clear about what mobile learning will mean in the future.

The second implication of the study is that although we focused on frameworks that explicitly addressed pedagogy, there is limited work that identifies what mobile learning pedagogy might mean, and the theoretical basis of a mobile learning pedagogy based upon specific learning theories needs significant further development. Mobile learning is at a crossroads. It may fade away as an area of research and practice or it may find new impetus in changing perceptions of how learning takes place when related to concepts of mobility. If the latter, then it is incumbent on the mobile learning research community to invest more effort into the theories and pedagogy that truly define the mobile learning experience and how it can be made more unique and effective in a changing landscape of technology-enhanced learning.

Mobile learning has initiated a shift in educational delivery for more than two decades now. The growth of mobile technologies provided opportunities to learn anytime and anywhere. Existing learning theories and various pedagogies have been employed to support this new way of educational delivery with different levels of success each time. However, the promise of mobile learning theory suggests that its full potential has not yet been met. Technological advances such as wearable devices, extended reality, the Internet of Things and artificial intelligence continue to grow and promise even more innovations in education. Future research is needed that can address the fragmented nature of current mobile learning frameworks to provide a more unified and consistent view of mobile learning and its associated theories and pedagogies, and perhaps bring in new aspects of mobile learning that take account of the opportunities and affordances of evolving mobile technologies.

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Table 1: Summary of the selected studies

No.	Author(s)	Publication Year	Title	Framework	Pedagogy
1	Al-Hunaiyyan, A., Bimba, A. T., Idris, N., & Al-Sharhan, S.	2017	A cognitive knowledge-based framework for social and metacognitive support in mobile learning	A framework for social & meta-cognitive support consisting of two algorithms: meta-cognition algorithm & social group mapping algorithm	Mobility of students across time, space, & content, with instant access to information and colleagues; flexibility & ubiquity; social & metacognitive support
2	Buckner, E., & Kim. P.	2014	Integrating technology and pedagogy for inquiry-based learning: The Stanford Mobile Inquiry-based	The Stanford Mobile Inquiry-based Learning Environment (SMILE)	Formulating questions in an inquiry-based collaborative learning context (constructivist)

			Learning Environment (SMILE)		
3	Cochrane, T.	2016	Mobile VR in Education: From the Fringe to the Mainstream	Mobile VR framework mapping an ecology of resources (mobile VR-EOR) & triggering events approach to new pedagogies	Rhizomatic learning with social constructivism, heutagogy, authentic & situated learning & connectivism
4	Cochrane, T., & Rhodes, D.	2013	iArchi[tech]ture: Developing a mobile social media framework for pedagogical transformation	Moving from pedagogy to heutagogy	Shift from pedagogy towards heutagogy, from instructivist to social constructivist

5	Crompton, H.	2017	Moving toward a mobile learning landscape: presenting a mlearning integration framework	Integration of mobile devices in teaching & learning	Teacher-centered to support the integration of mobile technologies; focus on educators’ beliefs, resources, methods & purpose
6	Dennen, V.P., & Hao, S.	2014	Intentionally mobile pedagogy: the M-COPE framework for mobile learning in higher education	The M-COPE (Mobile affordances, Conditions, Outcomes, Pedagogy and Ethics) framework for mobile learning in higher education	Instructional systems design, inquiry-based pedagogies, collaborative questioning; social constructivism
7	Kearney, M., Schuck, S., Burden, K., & Aubusson, P.	2012	Viewing mobile learning from a pedagogical perspective	iPAC, (Personalisation, Authenticity, Collaboration) but not identified as such in this paper	Authenticity, personalisation & collaboration along with six subscales

8	Khaddage, F., Christensen, R., Wing, L., Knezek, G., Norris, C., & Soloway, E.	2015	A model driven framework to address challenges in a mobile learning environment	Guiding mobile learning implementations confronting the pedagogical, technological, research & policy challenges	Agency, learner control, situated & context-based learning
9	Lai, K-W., Khaddage F., & Knezek, G.	2013	Blending student technology experiences in formal and informal learning	Mobile-Blended Collaborative Learning model	Collaboration, coordination & communication; bridges formal & informal learning, on-demand, inquiry & problem-based learning
10	Moya, S. & Camacho, M.	2021	Developing a framework for mobile learning adoption and sustainable development.	A framework for the adaption and sustainable use of mobile learning based on an adaptation of a strategic	Some pedagogies are broadly discussed, including collaboration, personalisation, and authenticity, but not

				management framework by Jauch and Glueck.	integrated into the framework explicitly
11	Ng, W., & Nicholas H.	2013	A framework for sustainable mobile learning in schools	Person-centred sustainable model for implementing mobile learning in an educational institution	Not specified
12	Nikou S.A. & Economides, A.A.	2021	A Framework for Mobile-Assisted Formative Assessment to Promote Students' Self-Determination	A three-layer framework that implements various pedagogical practices utilising the affordances of mobile technologies to enhance student motivation	Context-awareness, situated and authentic learning, collaboration, microlearning, interactive feedback provision, project-based learning

13	Okai-Ugbaje, S.	2021	Towards a pedagogical and sociotechnical framework for the strategic integration of mobile learning in higher education in low- and middle-income countries	A roadmap for the strategic integration of m-learning in higher education, considering the pedagogical & socioeconomic context of low- & middle-income countries	Social constructivism & the theory of optimal experience (Flow); student-centred, collaborative learning
14	Park, Y.	2011	A pedagogical framework for mobile learning: Categorising educational applications of mobile technologies into four types	Categorising educational applications of mobile technologies into four types adapted from Transactional Distance Theory	Curricula structure, communication & learner autonomy; individualised & socialised learning

15	Shamsuddin, S.N.W., Abu Bakar, N.F., Makhtar, M., Makhtar, M., Wan Isa, W.M., Rozaimee, A., & Yusof, N.	2016	A framework for designing mobile quranic memorization tool using multimedia interactive learning method for children	A Conceptual Framework for Designing Mobile Quranic Memorization Tool using Multimedia Interactive Learning Method	Game-based rote learning
16	Tan, Q., Zhang, X., Pivot, F.C., Evans, J., Kinshuk, & McGreal, R.	2016	The 5R Adaptation Framework: Concepts, Systems, and Learning Scenarios	The 5R adaptation for location-based mobile learning: at the right time, in the right location, through the right device, providing the right contents to the right learner	Location-based learning; cognitive- behaviorist, social constructivist, & connective pedagogies in distance education

17	Yin, C., Song, Y., Tabata, Y., Ogata, H. & Hwang, G-J.	2013	Developing and Implementing a Framework of Participatory Simulation for Mobile Learning Using Scaffolding	Scaffolding participatory simulation for mobile learning (SPSML) to help learn conceptual knowledge	Constructivist; participatory simulations & experiential learning; learning using AR & interaction with people in the real world to enhance understanding of conceptual knowledge, e.g., sorting algorithms
18	Zidoun, Y., Dehbi, R., Talea, M., & El Arroum Hassan, F.	2019	Designing a theoretical integration framework for mobile learning	5 axes framework for integrating ML into the curriculum (pedagogy, learner's profile, learning environment, continent, & mobile technology)	Pedagogy - central to mobile learning implementation; student-centred learning, collaborative learning, flexibility, and personalisation