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Design Principles of Mobile Learning Frameworks

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ABSTRACT

Numerous studies show positive cognitive and affective results regarding the adoption of mobile learning; however, adoption levels are low, and when mobile learning occurs, it is not always based on innovative pedagogies. The main objective of this study is to identify and analyse key design principles to develop a model for the adoption of mobile learning in education. This research is based on a systematic review of 20 publications. The findings reveal that most of the current studies focus on the adoption of mobile learning and the design and development of systems and applications. Additionally, these are mostly aimed at educators and instructional designers. Finally, the main dimensions that support the theoretical frameworks are the collaborative, social and communicative, contextual and spatial, pedagogical, technological, and strategic dimensions. Based on these findings, this study presents seven design principles for the adoption of mobile learning.

KEYWORDS

Design Principles, Mobile Learning, Systematic Review, Theoretical Frameworks

INTRODUCTION

The digitalization of the world is unstoppable. Many current jobs will disappear in a period not exceeding 15 years because they demand skills and competencies that differ greatly from those being learned in the classroom (Horn, 2014; Mourshed, Farrell, & Barton, 2013). The educational community faces the challenge of adapting these demands to the labour market, which requires innovative learning strategies (Ada, 2018; Ako-Nai, Tan, & Pivot, 2012; Churchill, King, Webster, & Fox, 2013; Crompton & Burke, 2018a; Sharples & Pea, 2014).

There are numerous mobile learning definitions, and most of them highlight core characteristics and functionalities such as accessibility, ubiquity, interaction, contextualization and personalization (Cochrane, 2010; El-Hussein & Cronje, 2010; Grant, 2019; Koole, 2009; McDonald et al., 2018; Milrad et al., 2013; H Peng et al., 2009; Sharples et al., 2010). These characteristics enhance some of the fundamental learning principles published by the OECD and based on both cognitive, emotional and biological perspectives (Dumont et al., 2010): learners at the centre; the social nature of learning; emotions are integral to learning; recognizing individual differences; stretching all students; assessment for learning; and building horizontal connections (Grant, 2019; A. Herrington et al., 2009; Khaddage et al., 2016; Sharples et al., 2010)The positive cognitive and affective benefits of mobile learning have been demonstrated in numerous studies (Chee et al., 2017; Crompton & Burke, 2018b; Hwang,

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2014; Islam & Grönlund, 2016; Liu et al., 2008; Mahdi, 2018; Núñez et al., 2015; Pimmer et al., 2016; Sung et al., 2016; Virtanen et al., 2017; Wu et al., 2012; Zheng et al., 2018).

Despite this, only 14% of European teachers use technology in more than 50% of their classes (TALIS, 2014). In Europe, on average, only 20-25% of students were taught by digitally safe and supportive teachers (European commission, 2013, p. 14). Some authors argue that age is a factor to consider; in general, teachers over 50 are less likely to allow the use of mobile devices in their classes than younger teachers (O'bannon & Thomas, 2014).

Some studies show the lack of current research on frameworks and models used for mobile learning adoption (Alrasheedi & Capretz, 2015; Keengwe, 2007; Keengwe et al., 2008; Miltenoff et al., 2013; Nikolopoulou & Gialamas, 2016; Rikala, 2015; Stevenson et al., 2015; Vahtivuori-Hänninen et al., 2012; Voogt et al., 2013). "The educational community needs a solid theoretical basis for mobile learning and more guidance on how to use technologies and integrate them into their teaching more effectively" (Alsaadat, 2017, p. 15). Some previous studies have been based on the systematic review of the literature or meta-analysis to analyse the main characteristics and trends of mobile learning, such as educational levels, participants, trends in research, mobile learning devices, methodologies used in research purposes or results (Crompton et al., 2019; Fu & Hwang, 2018; Krull & Duart, 2017). Some authors have included other mobile learning frameworks in their literature review (Ada, 2018; Lim Abdullah et al., 2013), but no systematic review of ml frameworks has been found. A review of the academic literature shows the need to develop a theoretical framework for the design of effective models for the adoption and sustainable use of mobile learning in education. Existing models for mobile learning adoption have certain limitations. Most of the mobile learning studies focus on learners and educators (Krull & Duart, 2017; Wu et al., 2012). Fundamentally, the target groups investigated have been students (Mahdi, 2018; Sun & Looi, 2018; Tingir et al., 2017). Strategies that drive significant changes in education are the responsibility of the entire educational community and each one has its role. Mobile learning frameworks have the challenge of evaluating its effectiveness in acquiring and presenting knowledge and there is no consistency in the validity of mobile learning frameworks (Ada, 2018). The present study focuses on covering the preliminary phases of this need. The main objective of this study is to identify and analyse key design principles to develop a model for the adoption and sustainable use of mobile learning in education.

RESEARCH QUESTIONS

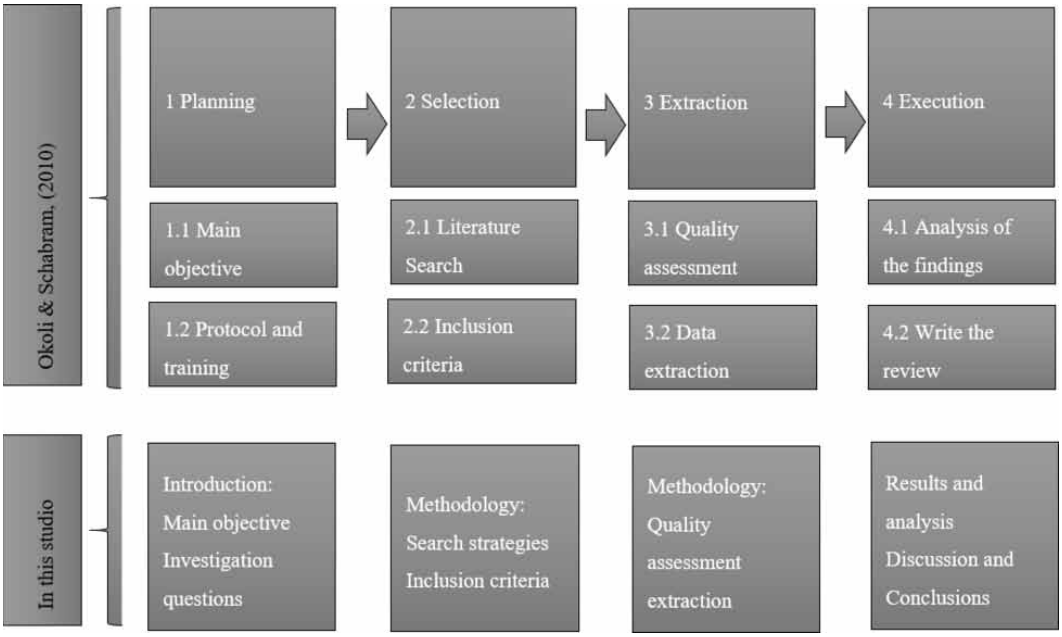
The research questions that guide this study to respond to the main objective of identifying and analysing design principles to develop a model for the adoption and sustainable use of mobile learning in education are as follows:

1. What are the most relevant characteristics of the theoretical frameworks used for mobile learning?
2. What are the main design principles used for the development of frameworks for the adoption and sustainable use of mobile learning?

METHODOLOGY

This study is based on the methodology proposed by (Okoli & Schabram, 2010), which is used to structure and organize the systematic review of the literature, and the process is illustrated in Figure 1. The authors themselves define the methodology as "a step-by-step approach to carry out the rigorous and scientific methodology of a systematic literature review" (Okoli & Schabram, 2010, p. 38).

Figure 1. Systematic process (Adapted from Okoli and Schabram, 2010, p. 9)



Search Strategy

The literature search was based on specific concepts (Webster & Watson, 2002). Table 1 shows the different sources consulted during the search for documents in the systematic review of the literature. The terms "mobile learning" or "m-learning" and "framework" or "model" were used. The terms were searched for in titles, keywords, and summaries in the sources that allowed these filters: SCOPUS: (TITLE (mobile AND learning) OR TITLE (m-learning) AND TITLE (framework) OR TITLE (model)); Web of Science: TS = (mobile learning) OR TS = (M-learning) AND TS = (framework) OR TS = (model); Google Scholar, referring exclusively to the title of the document: allintitle: "model" OR "framework" AND "mobile learning" OR "m-learning". Table 1 shows the selection process used for the different sources.

Although this study focuses primarily on theoretical frameworks, to identify frameworks, models were also included in the search. The frameworks describe the conceptual interactions between components and ideas based on related concepts, while the models provide a descriptive representation of the association between the elements included in a theoretical framework (Hsu & Ching, 2015).

Inclusion Criteria

1. In the generic field of education, exclude specific learning, such as language learning.

Table 1. Sources consulted and the application of criteria

Source	Search	Criteria
SCOPUS	230	15
WOS Web of Science	140	12
Google Scholar	90	17

2. Exclude specific applications or functionalities, such as augmented reality.
3. Exclude articles on the design of highly technical applications or systems.
4. Exclude studies related exclusively to attitudes and perceptions.
5. Exclude studies not referring theoretical frameworks and those focusing on specific models.

Quality Assessment

The criteria that were used to evaluate the quality of the publications are as follows:

1. They are based on academically relevant research methodologies.
2. They include a theoretical framework for the adoption of mobile learning with graphic representations.

The evaluation of the studies was carried out by two researchers and was based on the review of the summaries, keywords, and an analysis of the theoretical framework for the adoption of mobile learning. The research process initially yielded 412 publications. Applying inclusion criteria and quality assessment, search narrowed to 51 studies. Based on the article title, keywords and abstract, 24 articles were excluded for not being focused on mobile learning frameworks for education. A total of 27 full text articles were screened by the two authors. Studies not included in the selection but derived from the references of the first selection were also analysed such as TPACK. Finally, 20 studies were selected for this study. Table 2 shows the selected studies.

Data Extraction

Data extraction was performed by structuring the information so that the data could be used to provide answers to the research questions of the present study. A metadata with the following fields was prepared: author(s), study, title, source, name of the theoretical framework for the adoption of mobile learning, number of citations according to Google Scholar as of October 2019, main dimensions that support the model, purpose of the theoretical framework, and target audience to which the research is directed. The information was synthesized and analysed through the use of dynamic tables and graphs.

RESULTS AND ANALYSIS

The variables selected for the analysis were grouped into two categories. First, bibliometric data, the journals where the articles were published and the number of citations, were used to validate the relevance of the selected studies. In addition, the main constructs that support the theoretical frameworks, the dimensions, the purpose of the research and the audience to which it is addressed were analysed, with the main purpose of answering the research questions.

Bibliometric Results

Journals

Most of the studies analysed were published in prestigious journals in the field of technological education. Four of them are in the first quartile of the "Education and Educational Research" category according to the Journal Impact factor obtained from the Web of Science. Table 3 shows the details of the journals.

Citations

The number of citations is an important indicator used to measure the quality of research results (Leydesdorff & Shin, 2011; Luo, Sun, Erdt, Sesagiri Raamkumar, & Theng, 2018). There are few studies showing how to quantify a highly cited article. Wu et al. (2012) classified highly cited articles

Table 2. Mobile learning adoption frameworks

Study	Framework/Model
(Mishra & Koehler, 2006)	Technological Pedagogical Content Knowledge (TPACK)
(Motiwalla, 2007)	M-learning framework
(Liu et al., 2008)	Design framework for mobile learning
(Hsinyi, Yi-Ju, Chien, & Chin-Chung, 2009)	Conceptual framework of ubiquitous knowledge construction
(Koole, 2009)	Framework for the rational analysis of mobile education (FRAME)
(Sharples & Vavoula, 2009)	M3 evaluation framework
(Puentedura, 2009)	Situation, augmentation, modification, redefinition
(Nordin, Embi, & Yunus, 2010)	Framework for the mobile learning design requirements needed for lifelong learning
(Park, 2011)	Four types of mobile learning: a pedagogical framework
(Brummelhuis & van Amerongen, 2011)	Four in balance monitor
(Kearney, Schuck, Burden, & Aubusson, 2012)	Current framework comprising three distinctive characteristics of m-learning experiences
(Veerabhadram & Lombard, 2019)	A Mobile Design Framework for Continuous Mobile learning Environment in Higher Education
(Lim Abdullah, Hussin, Asra, & Zakaria, 2013)	Mlearning Scaffolding Five-stage Model
(Ng & Nicholas, 2013)	Person-centred sustainable model for mobile learning
(Hwang, 2014)	Framework of a smart learning environment
(Khalid, Jaafar, & Kasbun, 2015)	Framework Model of Mobile Learning Application using ADDIE Approach
(Rikala, 2015)	Mobile learning framework
Churchill et al. (2016)	Resources, activity, support and evaluation
(Crompton, 2017)	Cognitive knowledge/based framework for social and metacognitive support in mobile learning
(Ada, 2018)	Mobile Learning Framework for Assessment Feedback

as those with 13 or more citations. According to this classification, 18 of the 20 studies would fall into this category. Figure 2 shows the number of citations of the studies included in this research, measured during the month of October 2019 according to Google Scholar.

Results and Analysis of the Constructs

To synthesize and analyse the main dimensions of the theoretical frameworks, a thematic synthesis was carried out (Thomas, Harden, & Newman, 2012). A thematic synthesis is suitable for the analysis of research from different sources and can offer a common understanding. Thematic synthesis requires the application of thematic codes to all studies through an inductive and deductive process. The process is based on three phases: first, information is gathered and the studies are coded, and the second phase includes the organization of the codes "to develop and articulate relationships between

Table 3. Journals of the studies included in this research

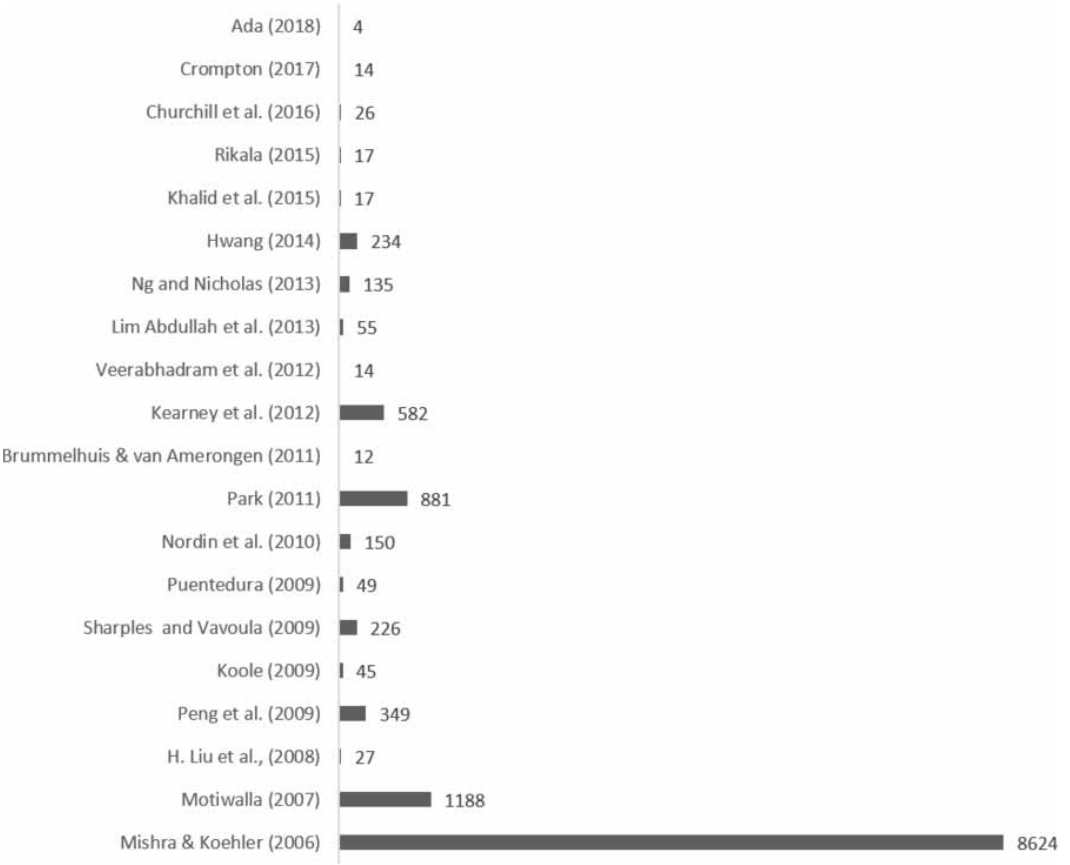
Study	Publication
Mishra & Koehler (2006)	Contemporary issues in technology and Teacher Education
Motiwalla (2007)	Computers & Education
H. Liu et al., (2008)	IEEE Conference proceedings
Peng et al. (2009)	Innovations in Education and Teaching International
Koole (2009)	Book
Sharples and Vavoula (2009)	International journal of mobile and blended learning
Puentedura (2009)	Web page
Nordin et al. (2010)	Procedia - Social and Behavioural Sciences
Park (2011)	The International Review of Research in Open and Distributed Learning
Brummelhuis & van Amerongen (2011)	Report
Kearney et al. (2012)	Research in learning technology
Veerabhadram et al. (2012)	International Journal of Scientific & Engineering Research
Lim Abdullah et al. (2013)	The Turkish online journal of educational technology
Ng and Nicholas (2013)	British journal of educational technology
Hwang (2014)	Smart Learning Environments
Khalid et al. (2015)	Australian Journal of Basic and Applied Sciences
Rikala (2015)	Thesis
Churchill et al. (2016)	Educational Technology
Crompton (2017)	Interactive Technology and Smart Education
Ada (2018)	Research and Practice in Technology Enhanced Learning

issues and associate conceptually similar issues with each other" (Thomas et. Al., p.196). The third phase is related to the creation of new conceptualizations.

To code the studies analysed, investigations with previous codifications were used.

Based on a systematic review, Wong & Looi (2011) suggested ten dimensions that characterize activities used for mobile-assisted learning (MLS): (MSL1) encompasses formal and informal learning; (MSL2) encompasses personalized and social learning; (MSL3) encompasses learning over time; (MSL4) encompasses the use of multiple locations; (MSL5) encompasses multiple access to learning resources; (MSL6) encompasses the physical and digital worlds; (MSL7) encompasses the combined use of multiple types of devices; (MSL8) encompasses continuous change between multiple learning tasks; (MSL9) encompasses knowledge synthesis; and (MSL10) encompasses multiple pedagogical models or learning activities. Other studies identified the characteristics of mobile learning: Klopfer, Squire, & Jenkins (2002) identified the following characteristics: portability, connectivity, social interactivity, individuality and fusion of the digital and physical worlds. (Traxler, 2010, p. 15) stated "Everyone can produce content to learn, and everyone can discuss it anywhere / anytime, just in time and just for them." (Khaddage, Müller, & Flintoff, 2016) identified the following characteristics: individualized, student-centred, located, collaborative, ubiquitous and continuous, similar to technology. (Burris, 2017) combined the framework for mobile learning experiences of (Kearney et al., 2012), which is included in the systematic review, and highlighted the following dimensions: authenticity, formal and informal learning, a combination of multiple tools and support in multiple pedagogies. Hsu & Ching (2015) carried out a review of mobile learning models and

Figure 2. Number of citations per study according to Google Scholar data, October 2019



frameworks. The study analysed 17 articles and classified them into five categories: pedagogies and learning environment design; platform/system design; technology acceptance; evaluation; and psychological construction. Based on the identified relationships, the dimensions were synthesized into four higher categories: pedagogical; collaboration, social and communication; environment and context and technology, as shown in the sixth column of Table 4. Table 4 shows the relationship between the different dimensions and proposes a new method of coding. The classifications and relationships were identified by two researchers, and the translations are their own.

Pedagogical Approaches

Several pedagogical approaches to learning can be identified in the 20 frameworks analysed, most of them based on constructivism as shown in Table 5.

Main Dimensions

From the previous analysis, four dimensions were identified: Pedagogical; technological; contextual & spatial; collaborative; and social & communicative.

Based on these dimensions, the second phase of the thematic synthesis process described by Thomas et Al. (2012) was performed. Each of the 20 studies included in the systematic review was classified based on the dimensions, the purpose of the research and the audience to which the research was directed. The classification was carried out by two researchers, and during this process, a new

Table 4. Main codifications of the dimensions of the theoretical frameworks of mobile learning

L. H. Wong & Looi (2011)	Klopfer, Squire, & Jenkins, (2002)	Traxler (2010, p.15)	Khaddage, Müller, & Flintoff (2016)	Hsu & Ching (2015)	Dimensions purposes
Covering formal and informal learning				Design of pedagogies & learning environments	Pedagogical
Embracing personalized and social learning	Individuality and social interactivity	Just for them	Personalization	Design of pedagogies & learning environments.	Collaborative / social / communicative
Over time		Anytime		Design of pedagogies & learning environments.	Pedagogical
Through multiple locations	Portability	Anywhere	Ubiquitous	Design of pedagogies & learning environments	Contextual, spatial
Multiple access & learning resources		Just in time		Design of pedagogies & learning environments	Contextual, spatial
Embracing the physical & digital worlds	Merging the digital & physical worlds		Situated	Platform/system design	Contextual, spatial
Combined use of multiple types of devices				Platform/system design	Technological
Continuous change between multiple learning tasks	Connectivity	Everyone can learn	Student-cantered	Design/evaluation of pedagogies & learning environments	Pedagogical
Synthesis of knowledge				Design of pedagogies & learning environments	Pedagogical
Covering multiple pedagogical models of mobile learning				Design of pedagogies & learning environments	Pedagogical
				Psychological construction	Pedagogical
				Technology acceptance	Technological

codification was identified and added to the previous four strategic elements. This codification focused on the objective, mission, values, leadership commitment, organizational communication and support of the educational community. Table 6 summarizes the second phase of the synthesis process.

Table 5. Pedagogical approaches

Pedagogical Approach	Framework
Action research	H. Liu et al., (2008)
Activity theory and constructivism	Individuality and social interactivity
Beviourist, constructivist, problem-based, context-awareness learning, socio-cultural theory and activity theory	Veerabhadram et al. (2012)
Constructivism	Crompton (2017); Lim Abdullah et al. (2013); Mishra & Koehler (2006); Motiwalla (2007); Nordin et al. (2010); Puentedura (2009); Rikala (2015); Sharples and Vavoula (2009)
Constructivism and life -long learning	Peng et al. (2009)
Constructivism, motivational theory, the technology acceptance model	Hwang (2014)
Not specified	Ada (2018); Brummelhuis & van Amerongen (2011); Churchill et al. (2016); Khalid et al. (2015)
Person-centred model	Ng and Nicholas (2013)
Socio-cultural perspective	Kearney et al. (2012)
The transactional distance theory	Park (2011)

All the studies analysed highlighted the Pedagogical dimension. Customization was relevant for four different frameworks (Hwang, 2014; Kearney et al., 2012; Nordin et al., 2010; Park, 2011); in their theoretical frameworks, the other studies refer indirectly to the observation of the student's needs (Ada, 2018; Koole, 2009; Liu et al., 2008; Rikala, 2015). These results are consistent with numerous studies that show positive results for the personalization of learning processes (Ferguson, 2011; Taylor & Burke da Silva, 2014). Hwang (2014) delves into the dimension of personalization and identifies three types of personalization: content, activities and support.

Based on the above, the first design principles for the development of a framework for adoption and sustainable use of mobile learning is to follow a pedagogical foundation that maximizes the excellent functionalities of mobile devices. Is guided by the pedagogical paradigm of constructivism, where the student is the center of learning, and learning is social and collaborative, considers individual needs, enhances personalization, and involves lifelong learning.In terms of the Pedagogical dimension, four studies refer specifically to the evaluation process (Ada, 2018; Churchill, Fox, & King, 2016; Hwang, 2014; Ng & Nicholas, 2013).

Include the evaluation of the models to be able to readjust and constantly evolve them is the second design principleOnly one model explicitly refers to teacher training as part of the Pedagogical dimension (Ada, 2018). Essentially, educators need assistance to be effective in integrating mobile learning, and assistance involves not only helping them learn how to operate the devices but also helping them plan mobile learning activities (Dennen & Hao, 2014, p. 398).

The third design principle for the adoption of mobile learning is to implement technology as a means rather than an end and ensure constant technological support.The second most cited dimension of the frameworks analysed is the environment & context. Different studies refer to different aspects of the environment & contextualization, such as the spatial location; temporal dimension; physical and virtual environments; influence of policies, economics; social, legal, technological availability; curriculum; and characteristics of students and teachers, among others (Ada, 2018; Crompton, 2017; Kearney et al., 2012; Koole, 2009; Lim Abdullah et al., 2013; Liu et al., 2008; Mishra & Koehler, 2006; Nordin et al., 2010; Peng, Su, Chou, & Tsai, 2009; Rikala, 2015). The frameworks seek to

Table 6. Dimensions and subdimensions of the frameworks for mobile adoption

Dimension/Subdimension	Publications
Collaborative, Social and Communicative	
Experience-centric	Sharples and Vavoula (2009)
Collaboration	Kearney et al. (2012)
Communication	Veerabhadram et al. (2012)
Communication & trust	Ng and Nicholas (2013)
Communication & Dialogue	Ada (2018)
Social interactions	Lim Abdullah et al. (2013), Rikala (2015)
Personalization	Park (2011)
Social	Crompton (2017), Koole (2009) Park (2011)
Social & Collaborative	Motiwalla (2007)
Contexual and Spatial	
Environment & Apprentice	Khalid et al. (2015)
Apprentice	Peng et al. (2009)
Authenticity / Contextualization	Kearney et al. (2012)
Content	Mishra & Koehler (2006)
Context	Lim Abdullah et al. (2013), Nordin et al. (2010)
Context (curriculum, implementation strategies & teaching skills)	Rikala (2015)
Environment Customization	H. Liu et Al., (2008), Hwang (2014), Koole (2009), Nordin et al. (2010), Rikala (2015)
Curriculum	Ada (2018)
Teacher's role, sociocultural influences, self-efficacy & experience	Crompton (2017)
Pedagogical	
Support for	Churchill et al. (2016), H. Liu et al., (2008)
Pedagogical support & training	Ada (2018)
Permanent learning	Peng et al. (2009)
Behaviourism, cognitivism, constructivism	Nordin et al. (2010)
Transactional distance	Park (2011)
Evaluation	Ada (2018), Churchill et al. (2016), Hwang (2014), Ng and Nicholas (2013)
Assessment instruments, content, lesson planning	Khalid et al. (2015)
Digital learning materials	Brummelhuis & van Amerongen (2011)
Transformation Improvement	Puentedura (2009)
Learning methods	Nordin et al. (2010)
Pedagogical methods	Peng et al. (2009)
Activities	Churchill et al. (2016)
Pedagogical	Mishra & Koehler (2006), Ng and Nicholas (2013), Rikala (2015), Veerabhadram et al. (2012), Lim Abdullah et al. (2013) Koole (2009) Crompton (2017)
Expertise	Brummelhuis & van Amerongen (2011)
Personalization	Ada (2018), Hwang (2014), Kearney et al. (2012), Motiwalla (2007)
Departure	Veerabhadram et al. (2012)
Technological	
Support for	Ng and Nicholas (2013)
Technological support	Lim Abdullah et al. (2013)
Training, technical support & access to technology;	Crompton (2017)
Device	Crompton (2017), Rikala (2015), Veerabhadram et al. (2012)
Economic	Ng and Nicholas (2013)
Tools	Peng et al. (2009)
ICT Infrastructure	Brummelhuis & van Amerongen (2011)
Resources	Churchill et al. (2016), Hwang (2014)
Resources & support	Ada (2018)
Media selection	Khalid et al. (2015)
Technological	H. Liu et al., (2008), Mishra & Koehler (2006), Nordin et al. (2010), Puentedura (2009), Sharples and Vavoula (2009)
Strategic Elements	
Goals & objectives	Khalid et al. (2015)
Mission, vision, and values	Brummelhuis & van Amerongen (2011)
Politician	Ng and Nicholas (2013)
View	Peng et al. (2009)

contextualize learning in authentic environments, which is consistent with other studies that have identified new concepts of learning spaces, such as organic gardens, gardens or living laboratories (Ferreira et al., 2014).

Next Design principle for adoption of mobile learning is to develop physical and virtual learning environments to authenticate and contextualize learning.

The dimensions related to social aspects, communication and collaboration environments were emphasized by nine studies (Ada, 2018; Crompton, 2017; Kearney et al., 2012; Koole, 2009; Lim Abdullah et al., 2013; Ng & Nicholas, 2013; Park, 2011; Rikala, 2015; Veerabhadram, de Beer, & Conradie, 2012). Koole (2009) pointed out that the social aspect considers the processes of interaction and social cooperation.

The fifth design principle for the adoption of mobile learning is permanently develop digital competence in all members of the educational community, especially teachers and students. Promote high levels of motivation and commitment, ensuring that the values of collaboration and cooperation encourage the exchange of resources and knowledge.

Most studies included the technological dimension. The authors used different approaches to refer to the technological dimension of their frameworks, such as devices, tools, technical support or ICT infrastructure (Ada, 2018; Crompton, 2017; Kearney et al., 2012; Koole, 2009; Lim Abdullah et al., 2013; Ng & Nicholas, 2013; Park, 2011; Rikala, 2015; Veerabhadram et al., 2012).Three studies included strategic elements in their frameworks, including vision, mission, values, strategy design, implementation and monitoring results (Brummelhuis & van Amerongen, 2011; Ng & Nicholas, 2013; Peng et al., 2009).

The sixth and last design principle for the adoption of mobile learning is to set clear objectives aligned with the mission, vision, and values of the centre. Involve the commitment and support of all members of the educational community throughout the process: design, implementation, and monitoring. Develop regulations and protocols to ensure safety and minimize risks.

The following figure summarizes and quantifies the dimensions used in the analysed frameworks (Figure 3).

Most of the analysed frameworks focus on the adoption of mobile learning (65%); some specifically focuses on the design of learning activities or environments, and only one specifically focuses on the evaluation design. Figure 4 shows the distribution of the studies analysed.

Although the most frequent purpose of theoretical frameworks is the adoption of mobile learning, by analysing the target audience to which they are directed, it can be seen that these studies are mainly aimed at educators and designers (Figure 5). These findings are consistent with other mobile learning studies on research purposes showing that most studies focus on designing, developing and implementing mobile learning applications and evaluating the effectiveness of mobile learning (Krull & Duart, 2017; Wu et al., 2012). Few studies focus on the adoption of mobile learning from a holistic perspective, both in terms of the breadth of the dimensions on which they are based and of the participating agents.

The seventh design principle for the adoption of mobile learning is to follow a holistic approach aimed at a systematic change that is based on the pillars of the educational community: educators, students, leaders, families, and other members of the community including lawmakers, instructional designers, and system developers, among others.

DISCUSSION AND CONCLUSION

The third and last phase of the thematic synthesis process described by Thomas et al. (2012) is related to the creation of new conceptualizations, which are set out below.

This research is based on a review of 20 theoretical frameworks for the adoption and sustainable use of mobile learning. The study confirms that 20studies are aimed at creating theoretical frameworks for the adoption of mobile learning. The findings reveal that the quality of the studies as measured by the number of citations and the quality of the journals where they have been published is high.

The main characteristics of the theoretical frameworks analysed are the following: the main purpose of the studies analysed is the adoption of mobile learning and the design of technological

Figure 3. Dimensions of the theoretical frameworks of mobile learning

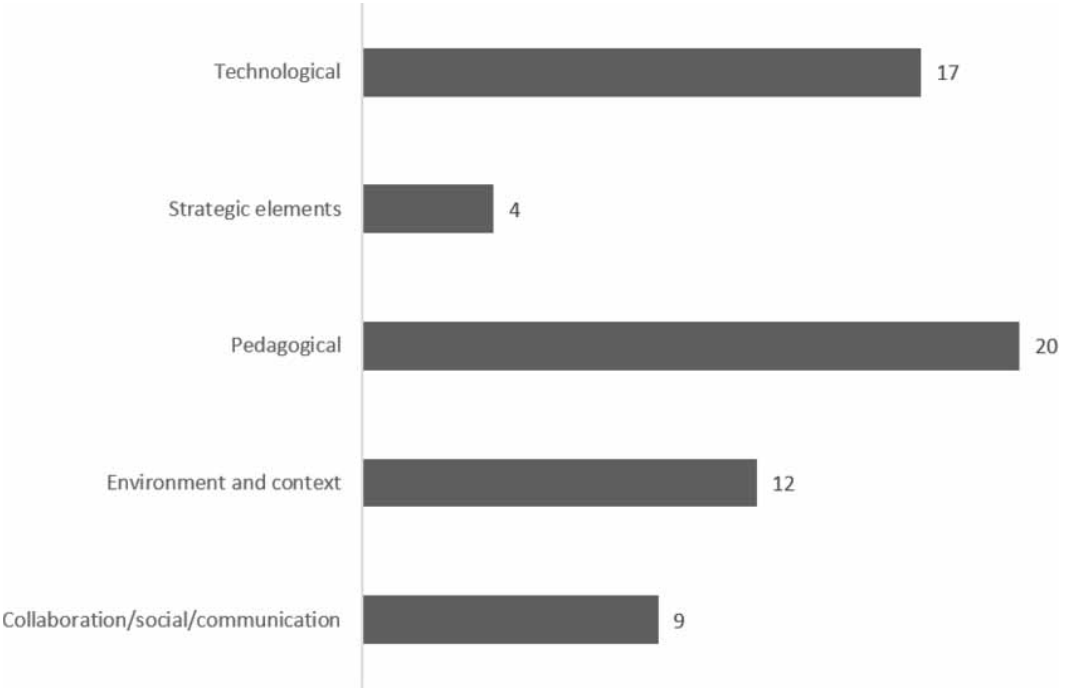


Figure 4. Purposes of the theoretical frameworks of mobile learning

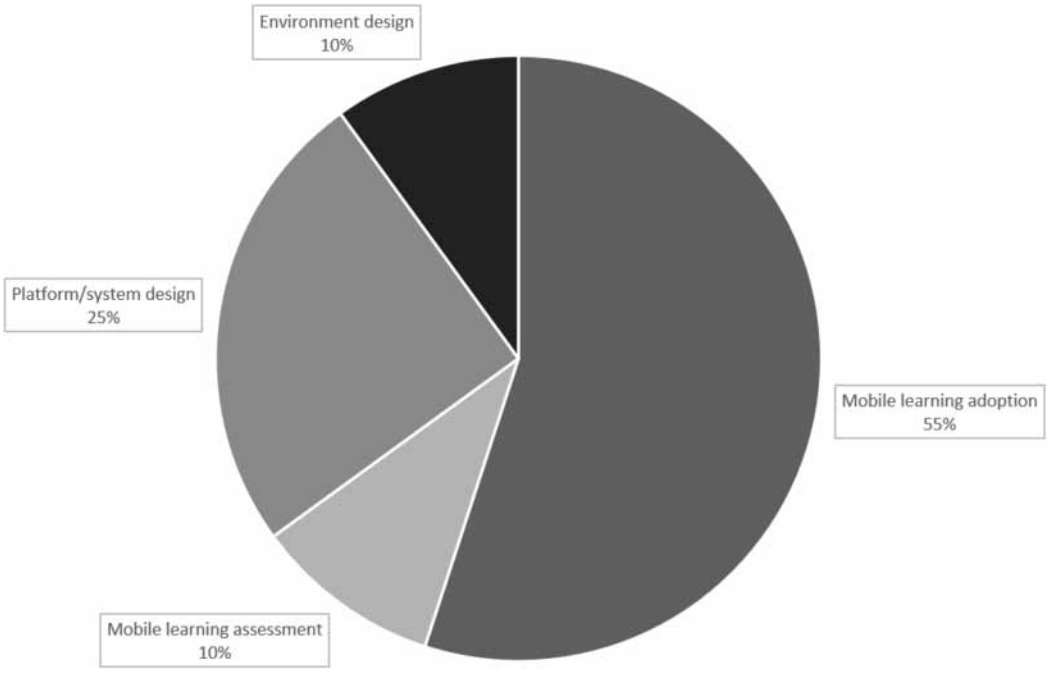
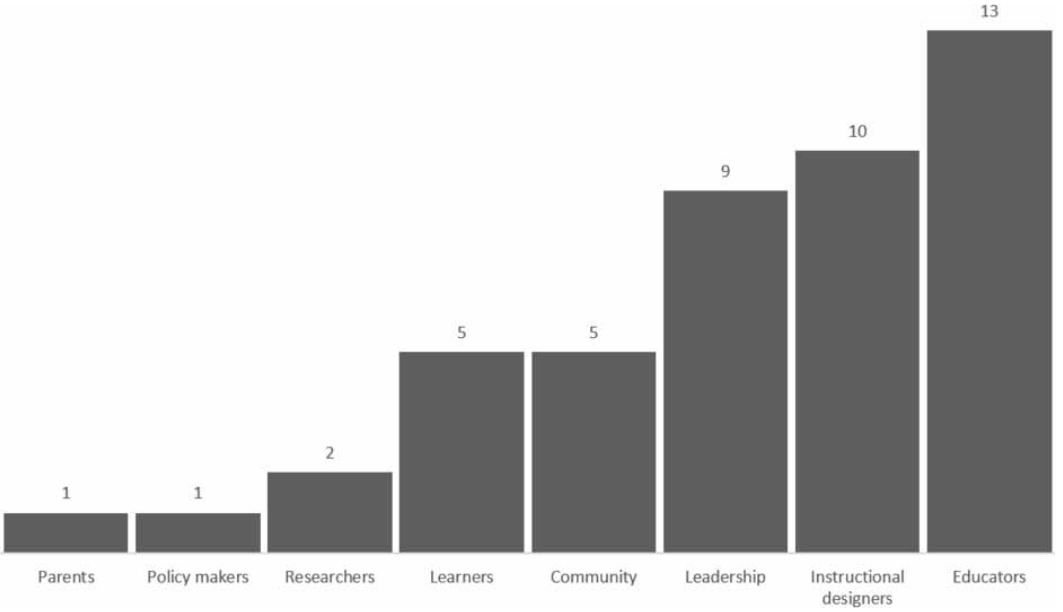


Figure 5. The target audience of the theoretical mobile learning frameworks



platforms; most studies are aimed at educators and instructional designers; the main dimensions used to support the theoretical models are the collaborative, social and communicative; contextual and spatial; pedagogical; technological; and strategic dimensions.The main contribution of this study is the identification of the seven main design principles for the adoption and sustainable use of mobile learning: pedagogical foundation; evaluation; implement technology as a means; develop environments to authenticate and contextualize learning; develop digital competence; set clear objectives and processes; and based on the pillars of the educational community: educators, students, leaders, families, and other members of the community including lawmakers, instructional designers, and system developers.

One of the main limitations of this study is that, due to the breadth and complexity of the literature, this study focuses exclusively on frameworks for the adoption of mobile learning and excludes leadership-oriented literature and management of the adoption of mobile learning. The findings are likely to change with ongoing technological development

Going forward, it would be beneficial for researchers to study the design principles in various educational contexts to see if there is anything omitted that needs to be added. The findings in this study can guide institutions as they face the challenge of adopting sustainable mobile learning.

Conflicts of Interest

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

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