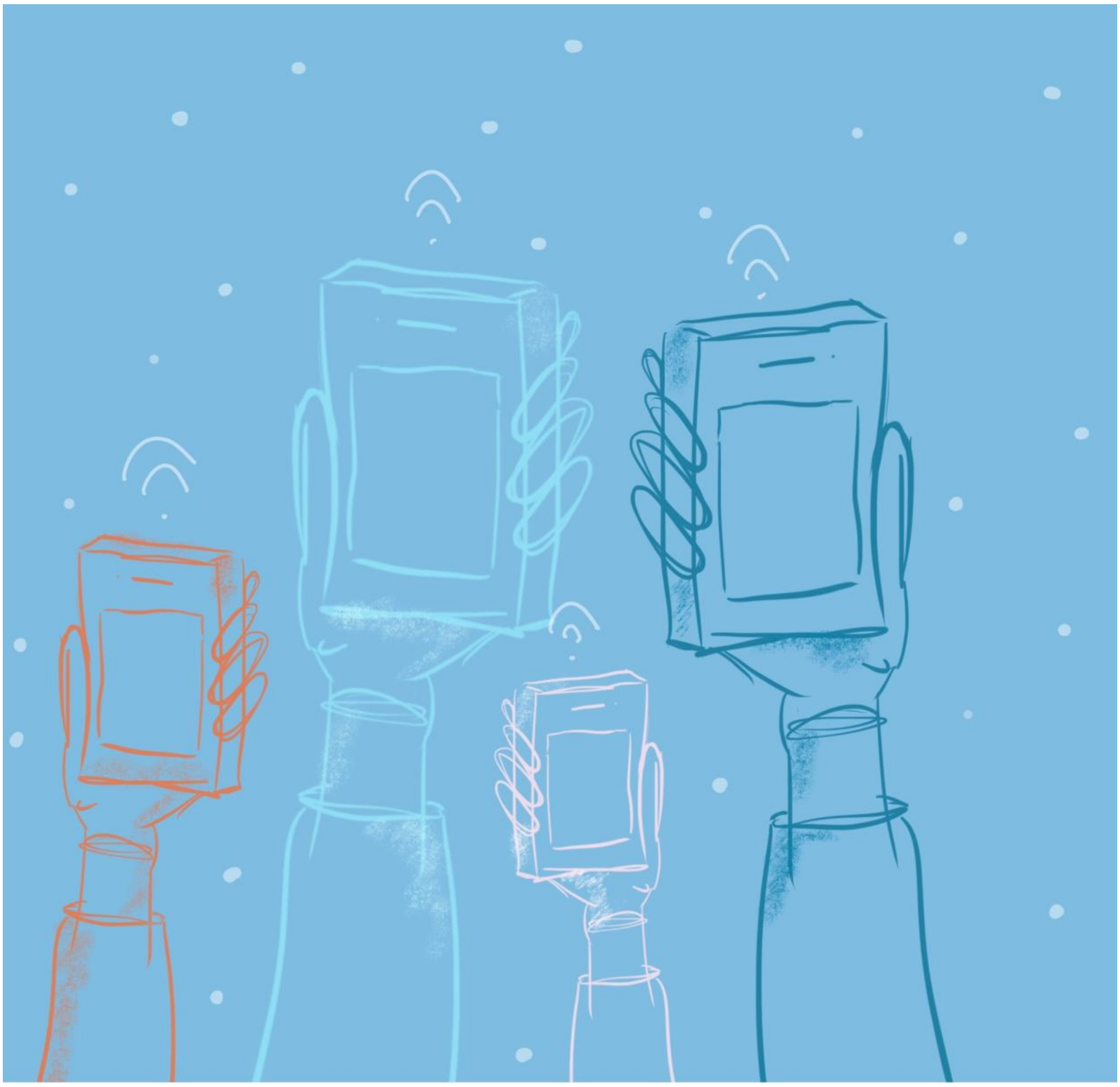
UNIVERSITAT ROVIRA I VIRGILI

Designing a framework for mobile learning adoption and sustainable development

Sofia Moya Pereira



UNIVERSITAT ROVIRA I VIRGILI
PH. D. THESIS

DESIGNING A FRAMEWORK FOR MOBILE LEARNING ADOPTION AND SUSTAINABLE DEVELOPMENT

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Universitat Rovira i Virgili, Tarragona

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Ph. D. Thesis

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I STATE that the present study, entitled "Designing a framework for mobile learning adoption and sustainable development" presented by Sofia Moya Pereira for the award of the degree of Doctor, has been carried out under my supervision at the Department of Pedagogy and that it satisfies all requirements to be eligible for the International Doctorate Award.

Tarragona, November 2020

Dr. Mar Camacho i Martí

Doctoral Thesis Supervisor

“I hear and I forget.
I see and I remember.
I do and I understand”

Confucious

«El puente entre este hoy y ese mañana que queremos tiene un nombre y se llama educación»
José Mujica

“Technology will not replace great teachers but technology in the hands of great teachers can be transformational”
George Couros

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LIST OF PUBLICATIONS RESULTING FROM THIS THESIS

Published Journal Articles

1) **Moya, S.**, & Camacho, M. (2020). A taxonomy of Mobile Learning based on Systematic Review. *International Journal of Mobile Learning and Organization*, 14(4), 425–455. https://doi.org/10.1504/IJMLO.2020.10030686

2) **Moya, S.**, & Camacho, M. (In press). Design principles of mobile learning frameworks. *International Journal of Mobile and Blended Learning*, *13*(1). https://doi.org/10.4018/IJMBL.202101xxxx

Articles under review

3) **Moya, S.**, & Camacho, M. A Framework for mobile learning adoption and sustainable development. *Journal of Technology, Knowledge and Learning*.

4) **Moya, S.**, & Camacho, M. . Identifying the key success factors for the adoption of mobile learning. *Education and Information Technologies*.

5) **Moya, S.**, & Camacho, M. Scorecard to evaluate and monitor mobile learning adoption. *Educación XXI*.

Published Conference Proceedings

6) **Moya, S.**, & Camacho, M. (2018). Planning to Implement Change: Strategic Pillars to Lead Mobile Learning in the Secondary School Environment. *Conference: International Conference on Open and Innovative EducationAt: Hong Kong*, 205–221. https://bit.ly/2keIkF8

7) **Moya, S.**, & Camacho, M. (2019). What factors matter most for mobile learning adoption? *Proceedings of the 15th International Conference on Mobile Learning 2019, ML 2019*. https://doi.org/10.33965/ml2019_201903l004

8) **Moya, S.**, & Camacho, M. (2020). Factores que afectan la adopción de mobile learning en Cataluña. In UMA editorial (Ed.), *XXIII Congreso Internacional Edutec* (pp. 783–786).

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9) **Moya, S.**, Camacho, M., & Palau, R. (2020). Cuadro de mando para el seguimiento en la adopción del mobile learning en educación. In U. A. de Barcelona (Ed.), *VI Congreso Internacional EDO 'La nueva gestión del conocimiento'*.

Presentations at Conferences

Moya, S., & Camacho, M. (2018). Planning to implement change: strategic pillars to lead mobile learning. In *International Congress for School Effectiveness and Improvement, ICSEI 2018*. Singapore.

Moya, S., & Camacho, M. (2018). Planning to Implement Change: Strategic Pillars to Lead Mobile Learning in the Secondary School Environment. *Conference: International Conference on Open and Innovative EducationAt:* Hong Kong.

Moya, S., & Camacho, M. (2018). What factors matter most for secondary schools succeed in Mobile learning. In *European Educational Research Association ECER 2018*, Bolzano, Italy.

Moya, S., & Camacho, M. (2018). Planning to implement change: strategic pillars to lead mobile learning. In *Ediciones de la Universidad de Lleida Asociación EDUTEC 2018*, Lleida, Spain.

Moya, S., & Camacho, M. (2019). What factors matter most for mobile learning adoption? *Proceedings of the 15th International Conference on Mobile Learning 2019*, Utrecht, The Netherlands.

Moya, S., Camacho, M., & Palau, R. (2020). Cuadro de mando para el seguimiento en la adopción del mobile learning en educación. In U. A. de Barcelona (Ed.), *VI Congreso Internacional EDO 'La nueva gestión del conocimiento'*.(Virtual participation)

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ACRONYMS

B-learning	Blended Learning
BSC	Balance Scorecard
BYOD	Bring Your Own Device
DBR	Design-Based Research
E-learning	Electronic Learning
ICT	Information and Communications Technology
iPod	Internet Portable Database
K-12	Kindergarten (K) and the 1st through the 12th grade
ML	Mobile learning
M-learning	Mobile learning
MP3	Moving Pictures Expert Group-Audio Layer 3
PC	Personal Computer
PDA	Personal Digital Assistant
PISA	Program for International Student Assessment
SWOT	Strengths, Weakness, Opportunities and Threats
TAM	Technology Acceptance Model
TPACK	Technological, Pedagogical and Content Knowledge
TPB	Theory of planned behaviour
ULearning	Ubiquitous Learning
UTAUT	Unified Theory of Acceptance and Use of
VUCA	Vulnerability, Uncertainty, Complexity and
TIC	Tecnologías de la Información y la Comunicación
CSF	Critical Success Factor
SD	Standard Deviation
M	Mean
LMS	Learning Management System
LD	Learning Design
MALL	Mobile Assisted Language Learning
SLA	Second Language Acquisition
CL	Cooperative Learning
MSL	Mobile Assisted Seamless Learning
RQ	Research Question
ULE	Ubiquitous Learning Environment

Designing a framework for mobile learning adoption and sustainable development

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ABSTRACT

The digitization of the world is unstoppable, the functionalities offered by mobile learning provide unlimited possibilities to improve learning, and the existing literature on mobile learning has proven positive results. However, there is a gap between the availability of technology and its use in education, even when it happens, it often does not optimize the results. There are few models for the adoption of mobile learning. In this context, the main objective of this research is to improve the adoption and sustainable use of mobile learning by developing a framework. Design-based research (DBR) is the methodology that guides this research. It has been developed in four design cycles to develop, test, and refine the theoretical framework for the adoption of mobile learning. The first design cycle identifies problems and research questions. During the second design cycle, the design principles are identified and based on these principles, the first prototype is developed. The third design cycle includes three iterations with the aim of testing and refining the initial design. A first iteration details the factors that affect the adoption of mobile learning in Catalonia and is based on an expert judgment. A second iteration validates and orders the identified factors, a questionnaire collects the perceptions of 147 teachers. Finally, a third iteration identifies the main indicators to evaluate and adjust the adoption of mobile learning and proposes a scorecard. Based on the three design cycles, the fourth cycle proposes design principles and presents a refined version of the first prototype of the framework. School leaders, teachers, students, families, and other stakeholders in the educational community have been identified as the key pillars to implement, sustain and optimize the adoption of mobile learning. The five dimensions that structure the theoretical framework are pedagogical; technological; contextual and spatial; social that includes behaviors, attitudes, and ethics; and leadership. The framework also highlights the relevance of evaluation and contextualization.

Keywords: mobile learning, ubiquitous learning; adoption factors, educational indicators, theoretical framework, expert judgement, learning development, design-based learning, research trends, success factors, systematic review, taxonomies, technology integration.

RESUM

La digitalització del món és imparable, les funcionalitats que ofereix mobile learning proporcionen possibilitats il·limitades per millorar l'aprenentatge, i la literatura existent sobre mobile learning ha evidenciat resultats positius. Tot i això, hi ha una bretxa entre la disponibilitat de tecnologia i l'ús en educació, fins i tot quan succeeix, sovint no optimitza els resultats. Existeixen pocs models per a l'adopció de mobile learning. En aquest context, l'objectiu principal d'aquesta investigació és millorar l'adopció i l'ús sostenible de mobile learning a través de la creació d'un marc teòric. Design-based research (DBR) és la metodologia que guia aquesta investigació. S'ha desenvolupat en quatre cicles de disseny amb la utilització de múltiples metodologies d'investigació per desenvolupar, provar i refinar el marc teòric per a l'adopció de mobile learning. El primer cicle de disseny identifica els problemes i les preguntes de recerca. Durant el segon cicle de disseny s'identifiquen els principis de disseny i en base a aquests principis, es desenvolupa el primer prototip. El tercer cicle de disseny inclou tres iteracions amb l'objectiu de testejar i refinar el disseny inicial. Una primera iteració detalla els factors que afecten l'adopció de mobile learning a Catalunya i es basa en un judici d'experts. Una segona iteració valida i ordena els factors identificats, un qüestionari recull les percepcions de 147 docents. Finalment, una tercera iteració va identificar els principals indicadors per avaluar i ajustar l'adopció de mobile learning, y proposa un quadre de comandament. Basat en els tres cicles de disseny, el quart cicle proposa principis de disseny i presenta una versió refinada del primer prototip de el marc per a l'adopció i l'ús sostenible de mobile learning. Els líders escolars, docents, estudiants, famílies i altres protagonistes de la comunitat educativa han estat identificats com els pilars clau per implementar, sostenir i optimitzar l'adopció de mobile learning. Les cinc dimensions que estructuren el marc teòric són la pedagògica; tecnològica; contextual i espacial; social que inclou comportaments, actituds i ètica; i lideratge. El marc també destaca la rellevància de l'avaluació i la contextualització.

Paraules clau: aprenentatge amb dispositius mòbils, mobile learning, aprenentatge ubic; factors d'adopció, indicadors educatius, marc teòric, judici d'experts, desenvolupament de l'aprenentatge, aprenentatge basat en el disseny, tendències d'investigació, factors d'èxit, revisió sistemàtica, taxonomies, integració de tecnologia.

RESUMEN

La digitalización del mundo es imparable, las funcionalidades que ofrece mobile learning proporcionan posibilidades ilimitadas para mejorar el aprendizaje, y la literatura existente sobre mobile learning ha evidenciado resultados positivos. Sin embargo, existe una brecha entre la disponibilidad de tecnología y su uso en educación, incluso cuando sucede, a menudo no optimiza los resultados. Existen pocos modelos para la adopción de mobile learning. En este contexto, el objetivo principal de esta investigación es mejorar la adopción y el uso sostenible de mobile learning mediante la creación de un marco teórico. Design-based research (DBR) es la metodología que guía esta investigación. Se ha desarrollado en cuatro ciclos de diseño para desarrollar, probar y refinar el marco teórico para la adopción de mobile learning. El primer ciclo de diseño identifica los problemas y las preguntas de investigación. Durante el segundo ciclo de diseño se identifican los principios de diseño y en base a estos principios, se desarrolla el primer prototipo. El tercer ciclo de diseño incluye tres iteraciones con el objetivo de testear y refinar el diseño inicial. Una primera iteración detalla los factores que afectan la adopción de mobile learning en Cataluña y se basa en un juicio de expertos. Una segunda iteración valida y ordena los factores identificados, un cuestionario recoge las percepciones de 147 docentes. Finalmente, una tercera iteración identifica los principales indicadores para evaluar y ajustar la adopción de mobile learning, y propone un cuadro de mando. Basado en los tres ciclos de diseño, el cuarto ciclo propone principios de diseño y presenta una versión refinada del primer prototipo del marco para la adopción y el uso sostenible de mobile learning. Los líderes escolares, docentes, estudiantes, familias y otros protagonistas de la comunidad educativa han sido identificados como los pilares clave para implementar, sostener y optimizar la adopción de mobile learning. Las cinco dimensiones que estructuran el marco teórico son la pedagógica; tecnológica; contextual y espacial; social que incluye comportamientos, actitudes y ética; y liderazgo. El marco también destaca la relevancia de la evaluación y la contextualización.

Palabras clave: aprendizaje con dispositivos móviles, mobile learning, aprendizaje ubicuo; factores de adopción, indicadores educativos, marco teórico, juicio de expertos, desarrollo del aprendizaje, aprendizaje basado en el diseño, tendencias de investigación, factores de éxito, revisión sistemática, taxonomías, integración de tecnología.

CHAPTER 1

INTRODUCTION

This chapter provides an overview of the main facets of the research in this thesis. First, the author introduces the subject and through the description of the motivations, justification, and identification of the problem, it shows that it is an investigation of interest, relevant and feasible. Then, the research proposal is presented, and the specific objectives are detailed. The research questions are detailed below in accordance with the objectives. After that, the research methodology is explained. This chapter concludes by describing the distribution of the structure of the thesis and the phases of the investigation including the contributions of this research. This chapter evidences the relevance of the study and the suitability of the research design.

1.1. Motivation and justification

This research is focused on designing a framework for sustainable adoption of mobile learning, rooted in innovative pedagogical strategies, aimed at all educational stakeholders.

The main motivation for the development of this research is personal and derived from the double condition of teacher and professional in an American multinational company of the researcher. What allowed me to identify a double gap. On the one hand, the very high level of digitalization in the professional world compared to the low level of curricular content aimed at developing digital competencies, both in the university and in secondary education. And on the other hand, the gap between the level and amount of technology that student's access and the low level of integration in their learning activities.

An additional motivation arose when the investigation was already in its last stages. The Governmental Department of Education Catalonia announced the project mòbils.edu, aimed at improving digital skills through the implementation of mobile learning in the last years of primary school and the first years of secondary school. The program is based on innovative technologies and strategies and is led by the general director of the department of education, director of this thesis and recognized expert in mobile learning, Dr. Mar Camacho, and Martí.

The initial reactions from the media, families, and schools, have not been as positive as expected for various reasons, which is an additional motivation to continue researching in the field of mobile learning and contributing to evidence its efficiency.

The rationale for choosing the topic is addressed from the following questions: because the integration of mobile learning is not extensive and effective. The digitalization of the world is unstoppable, and in parallel, the demand for digital talent continues to grow. According to a McKinsey report, "How to scale personalized learning" (Rawson et al., 2016), 22% of jobs are vacant because companies cannot find the right candidates with the required skills. Schools face the significant challenge of having to develop learning experiences to prepare students for the labour market, even if half of the jobs are expected to disappear in the future. Almost 40 percent of employers say a lack of skills is the main reason for entry-level vacancies (Mourshed et al., 2013). To make matters more complicated, work has also evolved from a requirement for basic technical knowledge to a demand for high multiple skilled workforces. More than 60% of all jobs require a high level of critical thinking, creativity, and interpersonal skills (Horn, 2014). Millions of jobs could be phased out, the day-to-day nature of work could change for nearly everyone as intelligent machines become fixtures in the workplace (Lund et al., 2019). In this context, there is a need for innovation toward the future of education, and digital approaches have a significant role.

One of the investment priorities laid down in the European Structural and Investment Funds Regulations contributing to the delivery of the Europe 2020 strategy for smart, sustainable, and inclusive growth is information and communication technology. Tallinn, Estonia, held the first EU Digital Summit in September 2017. The summit brought together EU heads of state. It was a platform that launched high-level discussions on further plans for digital innovation with the aim of keeping Europe ahead of the technological curve. Since 2005, the European Commission's science Knowledge service, launched the Joint Research Canter (JRC), research on Learning and Skills for the Digital Era, with the aim to provide evidence-based policy support to the European Commission and the Member States on harnessing the potential of digital technologies to innovate education and training practices.

Learning innovation in quality education includes digital approaches as catalytic converters that enhance learning and contribute to the development of 21st-century skills. There is a consensus among different key frameworks for 21st-century skills that digital will play a significant role. Esteve et al., (2013), in their study, proved that digital competency was included in all of the most significant 21st-century models they analysed: the SCANS Skills and Competencies, Definition and Selection of Competencies, enGauge 21st Century Skills, Literacy in the Digital Age, Framework for 21st Century Learning and Nurturing our Young for the Future, and Competencies for the 21st Century. Technological progress, infrastructure deployment, and falling prices have brought unexpected growth in ICT (Information and Communication Technologies) access and connectivity to billions of people around the world. "The rapid development of mobile learning has a significant impact on education". Al-Hunaiyyan et al. (2017, p. 4) in the Horizon Report on Higher Education, point out that knowledge construction must be supported by ICTs because they help design, create and work collaboratively.

Multiple device usage and BYOD (Bring Your Own Device) strategies are widely integrated into educational environments. According to Horizon report 2017, in the US, each student has on average 3.2 devices (Johnson et al., 2017). BYOD goes beyond access to devices, as students are no longer limited to institutional systems but increasingly have their own internet access and make use of their own services.

The exceptional characteristics of mobile learning provide functionalities that drive learning, specifically, enhance the adoption of the most innovative pedagogical paradigms such as constructivism or social constructivism. "Mobile technologies enable these resources to take on authentic contexts, moving between classrooms, laboratories and the external real world and used by students independently beyond their schools and whenever needed" (Churchill et al., 2016). "The presence of sensing technologies such as GPS (Global Positioning System), RFID (Radio-Frequency Identification) and QR (Quick Response) codes have further enabled learning systems to detect real-world locations and contexts of learners" (Hwang, 2014, p. 2).

Technological progress, infrastructure deployment, and falling prices have brought unexpected growth in ICT access and connectivity to billions of people around the world. In the third quarter of 2016 worldwide, mobile subscriptions reached 7.5 billion, a 97% penetration rate (Ewaldsson, 2016). Affordability and usability are progressing worldwide at a stunning speed. Cisco predicts that by 2021, there will be 27.1 billion internet-connected devices — three times the human global population. People expect to be able to learn and work anywhere, with constant access to learning materials (NMC/CoSN Horizon Report >

2017 K–12 Edition, 2017). Mobile devices penetration's levels will continue growing and BYOD model seems it is being installed in many areas including education. Accessibility and affordability are increasingly a less significant barrier in mobile learning adoption. Multiple device usage and Bring Your Own Device (BYOD) strategies are widely integrated into educational environments. The trend in the penetration of mobile phones and access to internet services continues to be positive.

According to the Digital 2019: Global Internet Use Accelerates report (Kemp, 2019) there are 5.1 billion unique mobile users in the world, what supposes a level of penetration in the world population of 67%, there are 4.4 billion internet users, 3.5 billion people use social media on mobile devices and 500 million tweets are sent every day. The extensive and ordinary use of mobile devices means it is feasible to have at least one device connected at any time, i.e., "1:1, 24x7" connectivity (Wong & Looi, 2011).

Today's students are considered digital natives, technology has become ubiquitous for students, especially outside of the educational environment. This provides a solid foundation to maximize digital potential to be used as a learning enhancement tool also in the classroom (Liyanagunawardena et al., 2013; N. L. Williams & Larwin, 2016).

BYOD and using its own internet services seem a strategy that will continue to be implemented (Traxler, 2016). According to Horizon report 2017, in the US each student has on average 3.2 devices, (NMC/CoSN Horizon Report > 2017 K–12 Edition, 2017). There are multiple studies proving positive results in BYOD to enhance learning and engagement (Song & Wen, 2018). These strategies involve risks, mainly associated with security, especially when it can compromise the confidentiality and integrity of corporate data (Armando et al., 2014). Usability and functionality are constantly evolving. For example, (Hochberg et al., 2018) demonstrated how build-in sensors incorporated in smartphones have multiple advantages for teaching and learning, by using smartphones as experimental tools. The growth in mobile technology development has also lowered the prices for mobile devices which allows them to be available to the majority of people (Ako-Nai et al., 2012).

Immediacy and connectivity enhance communication and social constructivism. The availability and accessibility to educational resources at any time enhance the development of a central and responsible role of the learner (Ada, 2018; Ng & Nicholas, 2013; Rikala, 2014; Walker, 2006). Technological progress in the form of infrastructure deployment, affordability and usability has brought unexpected growth in ICT access and connectivity to

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billions of people around the world.

The number of mobile learning publications has increased exponentially in the recent years (Krull & Duart, 2017; Moya & Camacho, 2020a; Ng & Nicholas, 2013; Wu et al., 2012).

There is consensus in recognizing the fundamental role of mobile devices in the technological revolution and the constant evolution towards powerful mobile devices, as well as intelligent software applications that improve our quality of life (Hargreaves & Fullan, 2012). A vast literature has proven multiple mobile learning positive benefits and impacts and has been recognized as one of the most influential technologies for education (Chee et al., 2017; Crompton & Burke, 2018; Hwang, 2014; Islam & Grönlund, 2016; H. Liu et al., 2008; Mahdi, 2017; Moya & Camacho, 2020a; Núñez et al., 2015; Pimmer et al., 2016; Y. T. Sung et al., 2016; Virtanen et al., 2018; Wu et al., 2012; Zheng et al., 2018). Pollara and Broussard (2011) conducted a systematic review analysing 21 mobile learning research studies and concluded that overall, the results were positive, and indicate several benefits, including the increase in achievement, productivity, engagement, and motivation. The engagement with educational applications of mobile technologies has also risen in recent years (Islam & Grönlund, 2016; Liaw et al., 2010; Pimmer, 2016). Specifically in the field of gamification , Connolly et al. (2012) conducted asystematic review of empirical evidence on computer games including 129 articles and concluded that the most frequently occurring outcomes and impacts were knowledge acquisition / content understanding and affective and motivational outcomes.

The adoption of technologies is a crucial element in the strategic process in the many institutions, and educational institutions are no exception. There has been considerable debate about the use of performance management tools in education, the literature shows that there are more examples demonstrating their value than there are detractors (Hernández-Ramos, 2014; Ng & Nicholas, 2013; Nikolopoulou & Gialamas, 2016). The literature shows successful cases of management-based strategies that have been initiated in the business world and are widely integrated into educational environments. Strategies such as strategic planning, human resources management, space management or specific technology strategies like BYOD, just to cite some (Camburn & Han, 2015; C. P. Chen et al., 2014; Dalziel et al., 2016; Dobozy, 2017; Ng & Nicholas, 2013; Penuel et al., 2011; Peurach & Neumerski, 2015; N. L. Williams & Larwin, 2016).

Identifying the critical factors in any field is an appropriate approach to management. Critical factors are crucial in the organization's strategies; managing factors affecting strategic management is part of the process and shape the efficiency and consistency (M. E. Porter, 1996). Critical factors definitions often relate to constructs or activities that must be managed in order to succeed in strategy (Goyal et al., 2010; Jauch & Glueck, 1988; Henry Mintzberg & Quinn, 2007; M. E. Porter, 1996). Goyal et al., (2010) defined critical factors as "Critical factors can be viewed as those activities and constituents that must be addressed in order to ensure its successful accomplishment and acceptance by the various stakeholders"(p.2).

During the process of preparing this thesis, the unfortunate situation of confinement resulting from the COVID 19 pandemic has had to be faced. This fact has meant an unprecedented boost in the digitization of education with multiple projects in many countries and in all educational stages. In Catalonia, the Mòbils.edu project., started in 2018, aimed at acquiring digital competence, accelerated achieving positive results in challenges as significant as the digital gap for students and teacher training (*mòbils.edu*, 2020) .

Previous experiences did not yield positive results. The first national policy plan for the adoption of technology in secondary schools was the European 1: 1 policy program, "School 2.0" of 2009. The main objective was to digitize classrooms, in secondary education. The plan would be implemented during the years 2009 to 2013, but it was suspended in 2012. According to a study by Fraga-Varela and Alonso-Ferreiro (2017) carried out on the School 2.0 project in Galicia, the results show a favourable opinion towards the implementation of models 1 to 1 in educational centres; however, they reflect a substantial degree of rejection of educational policies and reveal difficulties derived mainly from the lack of information and the training of teachers. These results are consistent with the results of the "1 to 1 Learning" study compiled by the European Schoolnet (EUN) through its network that involves policy makers, researchers and professionals from 30 Ministries of Education in Europe (Bocconi et al., 2013).

In summary, we can answer the question of why integrate mobile learning, based on three fundamental arguments: (1) the digitalization of the world is unstoppable, a relevant priority in many fields, including education (2) a vast literature has proven multiple mobile learning positive benefits, and (3) accessibility, usability and functionality have minimized some of the historical barriers such as cost or functional limitations.

1.2. Statement of the Problem

The research problem focuses on the need to develop a theoretical framework for the adoption and sustainable use of mobile learning in education.

According to the Teachers Teaching and Learning International Survey (TALIS) 2018 report (OECD, 2020), only 43% of teachers declare to be prepared or very well prepared for the use of technology in teaching, the lowest grade of all the dimensions evaluated. In Europe, the average is significantly higher than 50% and in the case of Spain, it drops to 38%. Moreover, about 18% of teachers across the OECD still express a high need for professional development in ICT skills for teaching. Finally, with 25% of school leaders reporting a shortage and inadequacy of digital technology for instruction as a hindrance to providing quality instruction, TALIS data suggest that teachers may be limited in their use of ICT.

In Europe, on average, only 20-25% of the students were taught by digitally safe and supportive teachers (European Commission, 2018, p. 14). “Although mlearning has a high prospect for future education, it is yet to be incorporated widely in mainstream formal education” (Lim Abdullah et al., 2013, p. 217).

Some authors argue that age is one factor to consider; in general, teachers aged over 50 are less likely to support the use of mobile devices in their classes (O’bannon & Thomas, 2014).

The speed at which technology evolves and pedagogical innovations requires a stable but flexible structure that allows constant adaptations. Society is constantly evolving, changing, the environment is characterized by its volatility, uncertainty, complexity, and ambiguity and requires constant changes, adaptations, and adjustments in many areas, including education (Bennett & Lemoine, 2014). The educational community faces the challenge of adapting these demands to the labour market, which requires innovative learning strategies (Ada, 2018; Ako-Nai et al., 2012; Churchill et al., 2013; Crompton & Burke, 2018; Sharples & Pea, 2014). Wallace (1994) referred to the need for flexibility to manage educational environments with the concept of rationalistic flexibility where plans are not implemented, rather they are made and remade as the school proceeds through a process of successive approximations to their goals.

Despite a large amount of evidence and consensus in the digitization of education, the reality of many classrooms is still significantly analogical. Although there is vast literature supporting that school technology integration must be part of a wider context, where pedagogical strategies are a crucial driver, the pedagogical use of powerful devices and digital resources is not yet optimized (Keengwe et al., 2008; Kopcha, 2012; Miltenoff et al., 2013; Motiwalla, 2007; Nikolopoulou & Gialamas, 2016; Park, 2011; Peng et al., 2009). The use of technology has increased in education, however, pedagogical practices haven't changed that much (Murthy et al., 2015). There is an apparent gap between the amount of technology available in today's classrooms and teachers' pedagogical use of that technology.

Mobile learning primarily use is to facilitate the delivery of content rather than to change educational patterns . "The unfortunate reality is that the majority of classrooms look the same way as they did 100 years ago and that the teachers mainly prefer conventional technologies to simply automate their traditional activities" (Rikala, 2014, p. 720).

Using technology with no functional improvement most likely does not improve students achievement Teachers who do use technology, primarily use it for low-level tasks, such as drill and practice programs or a free time activity (Crompton, 2017; Hsu et al., 2012). "merely transmitting information is insufficient for developing learning" (Mercader, 2018, p. 25). Many studies highlighted the potential benefits of mobile learning, such as personalized, contextualized across multiple fiscal and virtual environmental and not restricted by temporal or spatial constraints learning (Crompton, 2017) adapting into learning is a challenge (Mishra & Koehler, 2006; Ng & Nicholas, 2013; Rikala, 2015; H. Y. Sung et al., 2016).

Recognizing that the integration of mobile learning in education cannot be left in the introduction of devices, nor in the adoption of content, the challenge is how to adopt a pedagogical and strategic approach focused on improving learning (Islam & Grönlund, 2016; Miltenoff et al., 2013; Wives et al., 2016). Several authors highlighted the need to balance the physical adoption of mobile devices in classrooms with appropriate pedagogical designs (Ada, 2018; Kearney et al., 2012; Miltenoff et al., 2013; Ng & Nicholas, 2013; H. Y. Sung et al., 2016; Traxler, 2009). "Educators need to incorporate ways of leveraging the flexibility of boundary-crossing to enhance learning across a multitude of contexts by ensuring that both instructional materials and delivery methods are put into a mobile format and remain flexible in different usage environments and situations (Schuck et al., 2017).

Often, the challenge in adopting technology is focused on acceptance or rejection by people (Davis, 1989; Hamidi & Chavoshi, 2018). Many theoretical frameworks have been created to test user behaviour, and several models were identified during this research. Among the different models, Technology Acceptance Model (TAM) appears to be the one most applied in many research fields. The literature shows a broad consensus with regard to considering the adoption of technology to be a strategic process (Aguti et al., 2014; Lim Abdullah et al., 2013; Ng & Nicholas, 2013; Peng et al., 2009).

Some authors argue that the confusion in the definition of the concept of mobile learning and the lack of precision in the identification of its characteristics are obstacles for the scientific community to develop effective pedagogical theoretical frameworks (Baran, 2014; Grant, 2019). "The lack of a contemporary theory of learning and model for the mobile era has been one of the main issues hindering the incorporation" (Lim Abdullah et al., 2013, p. 217).

There is an evidenced and recognized the lack of current research in the field of frameworks and models for adoption of mobile learning (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). "Educational community needs a solid theoretical foundation for mobile learning and more guidance about how to use technologies and integrate them into their teaching more effectively" (Alsaadat, 2017, p. 15).

Recognizing the need for teachers to assist in the effective integration of mobile learning, there is still a lack of coherent and consensual models leads educators to a lack of guidance and confidence in the adoption of mobile learning in their classrooms (Ada, 2018; Parsons et al., 2016). "Instructional designers and teachers need a solid theoretical foundation for mobile learning as well as more guidance on the effective use and integration of mobile devices in their teaching (Park, 2011, p. 79). Most of mobile learning frameworks are techno-centric in nature, which are useful within the context of how mobile learning could be delivered technically but not attending to other relevant aspects (Krull & Duart, 2017; Kukulska-Hulme et al., 2009; Lim Abdullah et al., 2013; Ng & Nicholas, 2013; Sharples & Pea, 2014). "Mobile learning developments have tended to be more about the design of the tools than of the ensuing learning" (Kearney et al., 2012, p. 1). Most of the mobile learning literature has focused on effectiveness, the development of systems, influence characteristics and the affective domain (Al-Zahrani & Laxman, 2016; Crompton & Burke, 2018; Fu & Hwang, 2018; J.-L. Hung & Zhang, 2012; Krull & Duart, 2017; Wu et al., 2012).

Researchers have proved the positive impact of digital learning on leaders, students, teachers, and other educational community. Islam and Grünland (2016) conducted a review of

145 papers from the years 2000 to 2012 to accumulate evidence of uses and impact of computer learning, including any device, not just PC, most of their reviewed literature was focused on the articles of Fisher (2005-2010), Holomb (2003-2008) and Penuel (2001-2005). However, some authors focus on the lack of theoretical frameworks specifically aimed at some members of the community, education, "there is a lack of recommendations for educators, as the current research and practical recommendations are still in an embryonic stage" (Churchill et al., 2016). Most of the mobile learning studies are focused on learners and educators (Krull & Duart, 2017; Moya & Camacho, 2020a; Wu et al., 2012). Fundamentally, the target groups investigated have been students (Chee et al., 2018; Hwang & Tsai, 2011; Mahdi, 2018; Y. T. Sung et al., 2016; Tingir et al., 2017).

Often the responsibility for the adoption of mobile learning has fallen on the teachers and in the best case the instructional designers, but the relevance and dimension of the process, make it a challenge that has to be the responsibility of the entire educational community. Strategies that drive significant changes in education are the responsibility of the entire educational community and each one has its role. "Development planning is a response to the need for a systematic and whole-school approach to planning and the management of multiple innovations and change" (Hargreaves & Hopkins, 1994, p. 17).

There is no consistency in the validity of mobile learning frameworks. Mobile learning frameworks have the challenge of evaluating its effectiveness in acquiring and presenting knowledge (Ada, 2018; Al-Hunaiyyan et al., 2017; Moya et al., 2020; Veerabhadram et al., 2012). Few studies have explored holistically the elements that sustain mobile learning (Ng & Nicholas, 2013).

Very few frameworks consider crucial pedagogical aspects such an evaluation (Ada, 2018; Al-Hunaiyyan et al., 2017; Veerabhadram et al., 2012). Sustainability is a key success factor for the successful adoption of mobile learning and often is not the case. Most studies of mobile learning are short-term, funded projects where access to technical support and pedagogy are often predetermined through sponsorship (Ng & Nicholas, 2013). There is no continuous training, "Training empirical evidence shows that one-off training does not e

nough and training needs to be continued on a regular basis" (Crompton, 2017, p. 9). Research problems can be grouped into two categories, on the one hand, the current situation in relation to mobile learning from which these problems arise: (1) there is conceptual confusion about mobile learning and its characteristics; (2) mobile learning adoption levels are low; and (3) when it occurs, it is often inefficient and unsustainable, basically due to the lack of orchestration of fundamental elements such as pedagogical adaptation.

The second refers to the lack of models for the adoption and sustainable use of mobile learning, which highlights four problems: (1) lack of theoretical frameworks: (2) lack of a holistic theoretical framework that includes all dimensions and oriented to all stakeholders; (3) lack of sustainability in the models; (4) difficulty in evaluating the effectiveness of current models.

1.3. Aims of the thesis

This study aims to tackle the challenge of the lack of theoretical frameworks with pedagogical foundations for effective adoption and sustainable development of mobile learning in education. The main objective of this research is to enhance the adoption and sustained use of mobile learning by developing a strategic framework. In this context, the author of this thesis aims to address those issues by the following three specific objectives:

O1: Determine an explanatory model of the current situation of research in mobile learning.

O2: Identify the main characteristics, functionalities, and pedagogical benefits of mobile learning.

O3: Categorize and synthesize existing mobile learning frameworks and identify design principles.

O4: Identify and prioritize the critical success factors in mobile learning adoption and sustainable development.

O5: Designing a dashboard for evaluation and monitoring of mobile learning adoption.

O6: Designing a strategic framework for the adoption and sustainable development of mobile learning.

1.4. Research questions

Based on the objectives of this study, the research three principal questions are as follows:

RQ1. What is the current state of mobile learning research?

RQ2. What are the main characteristics and functionalities of mobile learning?

RQ3. What are the main design principles used for the development of frameworks for the adoption and sustainable use of mobile learning?

RQ4. What are the critical success factors for the adoption and sustainable use of mobile learning in education?

RQ5. What are the indicators and characteristics to develop a tool to evaluate and monitor the adoption of mobile learning?

RQ6. What are the core elements of a strategic framework for the adoption of mobile learning?

1.5. Structure of the thesis

This study is organized into seven chapters. The first refers to the introduction and analyzes the literature in the field of mobile learning, describes the context, identifies the statement of the problem, objectives, and research questions. The second chapter presents to the methodology employed. Chapters 3 to 6 referred to the different phases of the research design. Chapter 3 refers to the first phase aims to identify the current situation in mobile learning research and analyze the characteristics and functionalities of mobile learning. The fourth chapter correspond to the second design cycle in design-based research and establishes the initial design principles and develops an initial prototype of the mobile learning framework. In the fifth chapter the third design cycle is developed, three iterations have been developed to test and refine the initial prototype. The sixth chapter is the fourth design cycle of the investigation and presents the refined design principles and an improved mobile learning framework. Finally, Chapter seven concludes and discusses the results of the thesis. Figure 1. Structure of the thesis1 depicts the structure of the thesis.

JUSTIFICATION

1. The digitalization of the world is unstoppable, a relevant priority in many fields, including education
2. A vast literature has proven multiple mobile learning positive benefits
3. Accessibility, usability and functionality have minimized some of the historical barriers such as cost or functional limitations

Chapter 1

STATEMENT OF THE PROBLEM

1. Confusion ML concept and Characteristics
2. Low levels of ML adoption
3. Inefficient and unsustainable ML adoption
4. Scarce research on ML frameworks
5. Lack of holistic oriented to all stakeholders ML Frameworks
6. Lack of sustainable ML frameworks
7. Difficulty to evaluate ML frameworks effectiveness

Chapter 1

RESEARCH OBJECTIVES

O1: Determine an explanatory model of the current situation of research in mobile learning.
O2: Identify the main characteristics, functionalities, and pedagogical benefits of ML.
O3: Categorize and synthesize existing ML frameworks and identify design principles.
O4: Identify and prioritize the critical success factors in ML adoption.
O5: Designing a dashboard for evaluation and monitoring of ML adoption.
O6: Designing a strategic framework for the adoption and sustainable development of ML.

Chapter 1

RESEARCH QUESTIONS

RQ1. What is the current state of ML research?.
RQ2. What are the main characteristics and functionalities of mobile learning?.
RQ3. What are the main design principles used for the development of frameworks for the adoption and sustainable use of ML?.
RQ4. What are the critical success factors for the adoption and sustainable use of ML?.
RQ5. What are the indicators and characteristics to develop a tool to evaluate and monitor ML adoption?
RQ6. What are the core elements of a strategic framework for the adoption of mobile learning?

Chapter 1

RESEARCH DESIGN

Design cycle 1: Analysis of practical problems (RQ 1 and RQ2). Systematic review
Design cycle 2: Developing an initial ML framework based on design principles (RQ3). Systematic revies
Design cycle 3: Interactive cycles of testing and refinement the initial mobile learning framework (RQ4 and RQ5). Systematic review, expert judgement, and questionnaire
Design cycle 4: Improved mobile learning framework based on refined design principles (RQ6). Systematic review

Chapter 2

RESEARCH RESULTS

RQ1. Study 1:A taxonomy of ML based on a systematic review of research publications from 2009 to 2018
RQ2. Study 2: Características, funcionalidades y beneficios de m-learning: revisión sistemática de la literatura
RQ3. Study 3: Design principles of ML frameworks
RQ6. Study 4. Planning to implement change. Strategic Pillars to Lead Mobile Learning
RQ 4. Study 5: Identifying the key success factors for the adoption of mobile learning
RQ4. Study 6: What factors matter most for ML adoption?
RQ4 .Study 7: Percepciones de los docentes sobre la adopción de ML
RQ5. Study 8: Cuadro de mando para el seguimiento en la adopción del mobile learning en educación
RQ6. Study 9: A Framework for mobile learning adoption and sustainable development

Chapter 3- 7

Figure 1. Structure of the thesis

1.6. Research design

The design of this research is based on the phases of the DBR approach adapted for theses by Herrington et al. (2007) described in the next section. Each of these phases is equivalent to a chapter of the thesis and aims to answer the research questions of this study. The research design of this thesis is shown in the Figure 2. Thesis Research Design 2.

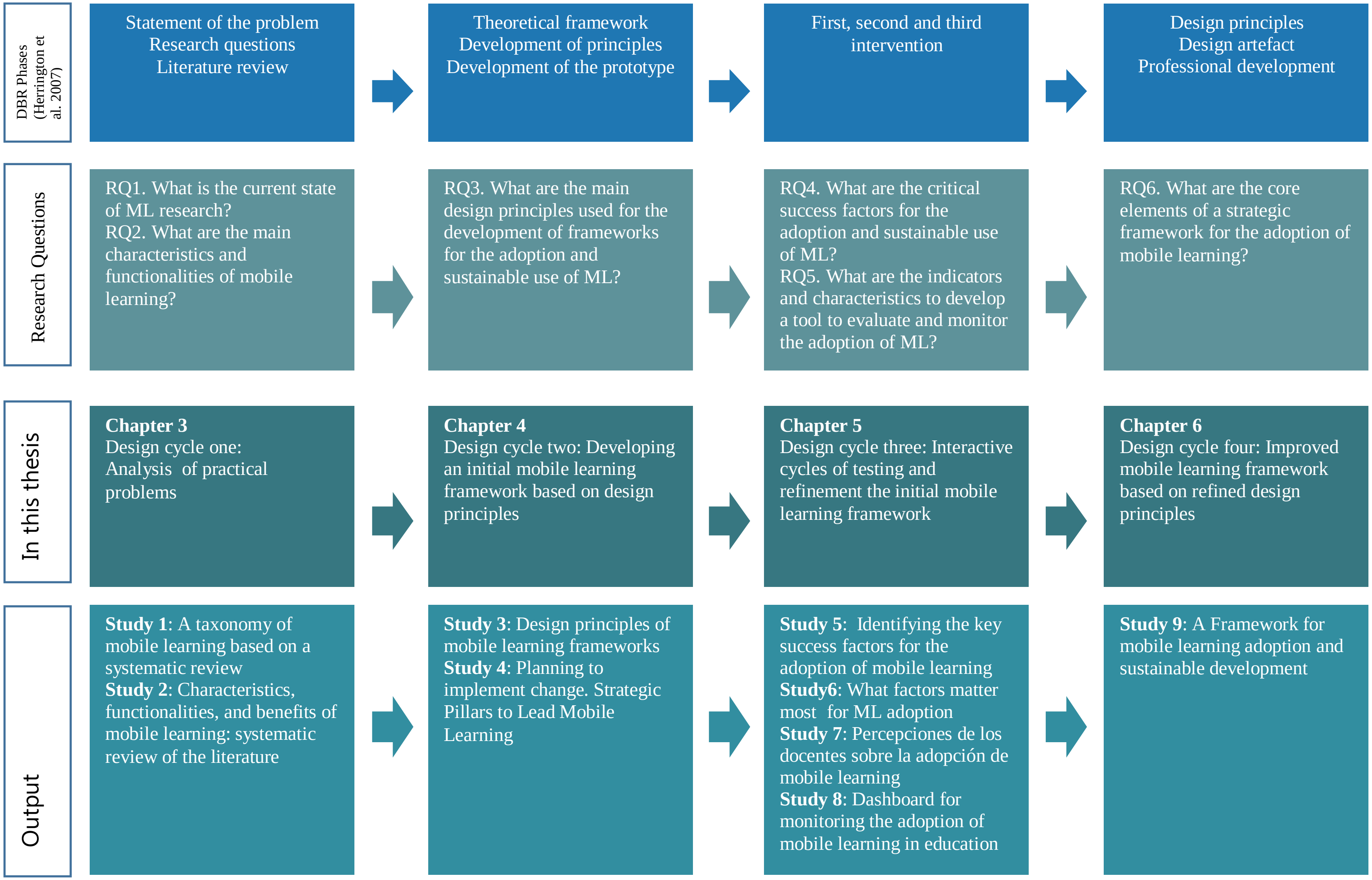


Figure 2. Thesis Research Design

Designing a framework for mobile learning adoption and sustainable development

CHAPTER 2

METHODOLOGY: DESIGN-BASED RESEARCH

2.1. Research methodology: design-based approach

This study is based on a design-based research approach (DBR). Barab & Squire, (2004) defined design-based research as "a series of approaches, with the intent of producing new theories, artifacts, and practices that account for and potentially impact learning and teaching in naturalistic settings" (p. 2).

From the general objective of research-oriented to the design of a theoretical framework for the adoption and sustainable use of mobile learning, it follows that the focus of this research is eminently applied since it seeks to contribute to solving a practical approach. Elliott (1993) defines action research as a study of a social situation to improve the quality of action. Despite this, during the initial phases of the research, the approach is exploratory, aimed at identifying and describing characteristics, both of mobile learning and of the theoretical frameworks for the adoption of mobile learning (Bisquerra, 2004).

Design-based approach is appropriate to design and technological innovations for education (Anderson & Shattuck, 2012). Wang & Hannafin (2005) defined design-based research as "a systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners in real-world settings, and leading to contextually-sensitive design principles and theories (p. 6)". They identify five key characteristics, first, it is pragmatic, its focus on practical problems and linked to a practical process. Second, design. Based research is grounded, is based on research and practice. Third design-based research is mainly interactive, iterative, and flexible. Fourth, design-based research incorporates different research methodologies. Finally, design-based research is contextual, it is linked to a specific research contextualization.

Kopcha et al., (2015) positioned design-based research (DBR) (Barab & Squire, 2004) into the education design-based research. The model has been evolving and continues to evolve towards more practical scenarios such as design-based implementation research (DBIR) (Penuel et al., 2011). "The use of design-based research methodology in educational contexts has increased over the past decade and mostly with educational technology innovations and interventions" (Anderson & Shattuck, 2012). Design-based research is conducted in real-world contexts due to the complexity of the problems it addresses (Hsu & Ching, 2015, p. 31). It is a much closer approach to active contribution and gives the opportunity to design theories, models and products, tested during the investigation (McKenney & Reeves, 2014).

One of the main objectives of those paradigms is to shorten the bridge between theoretical and practical approaches. Design and construction studies focus on presenting design frameworks along with the theoretical and empirical grounding (Herrington et al., 2007).

McKenney & Reeves (2014) referred to educational research as a process that consists of three phases (analysis, design, and evaluation) in a flexible, iterative structure, with a double focus on theory and practice (scientific and practical results) and with the purpose of its usability represented in Figure 3.

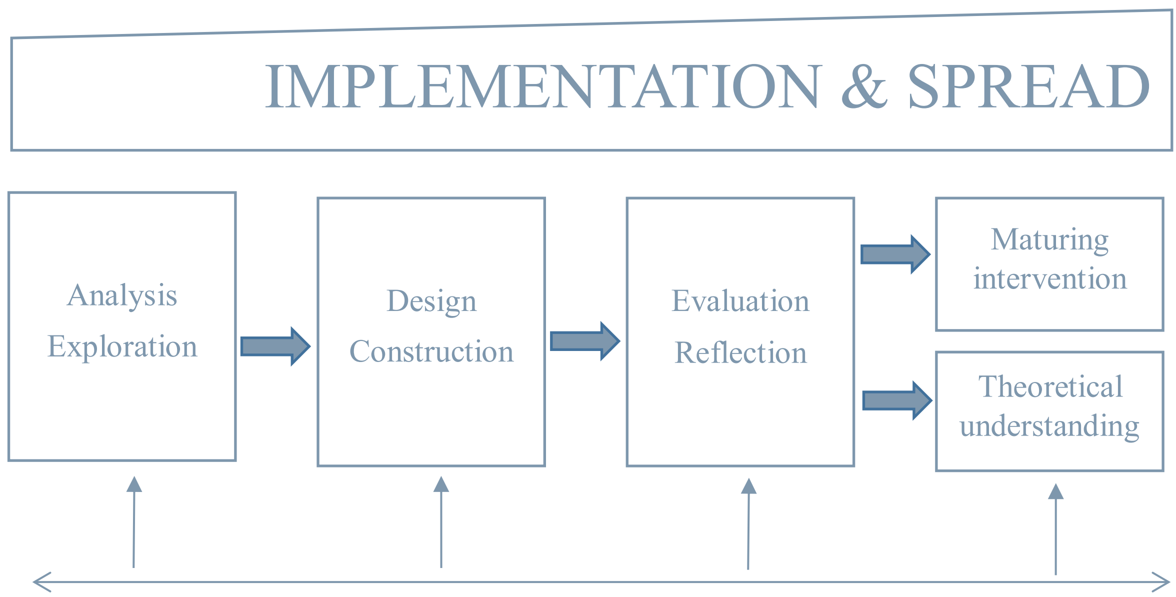


Figure 3. McKenney & Reeves (2014, p. 135.) generic model of Educational Design Research

Under this generic design of educational design research, the different approximations have been developed. Specifically, in terms of design-based research, Barab & Squire (2004) defined design-based research as "a series of approaches, with the intent of producing new theories, artifacts, and practices that account for and potentially impact learning and teaching in naturalistic settings" (p. 2).

This series of approaches have been identified and defined by many authors, mostly following a structure of analysis, design, and evaluation. Reeves (2006) shaped those approaches in a four-phase cycle represented in Figure 4. Design-based research (adapted from Reeves 2006, p.59).

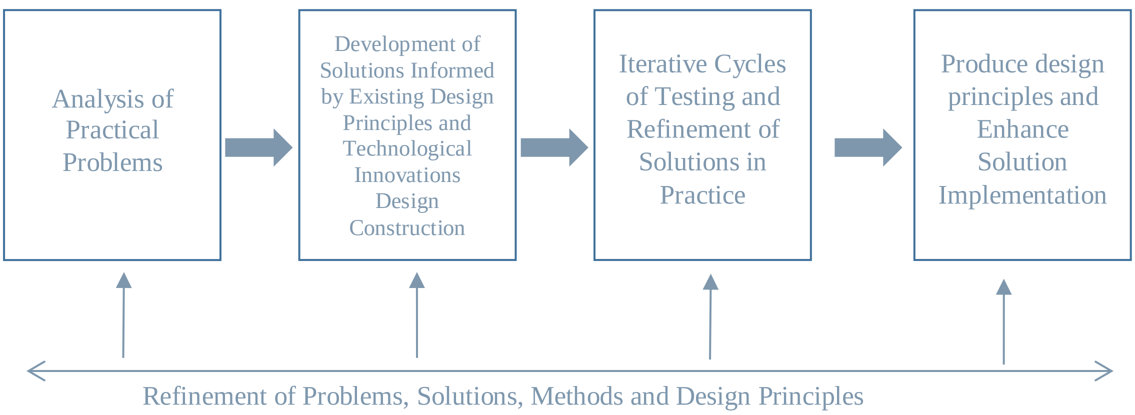


Figure 4. Design-based research (adapted from Reeves 2006, p.59)

The specific characteristics that characterize the design-based research have endorsed the suitability of this paradigm for this research. The main feature is an eminently practical approach that is reflected in most DBR features. This research seeks to develop a framework to implement mobile learning in real scenarios, as real actors and with a practical and efficient model. Anderson and Shattuck (2012) defined DBR with a description of the main characteristics:

Being situated in a real educational context. The research context must be real. It is a very real and practical approach where the results must improve the practice in those contexts.

Focusing on the design and testing of significant intervention. Interventions are informed by relevant literature, theory, and practice from other contexts; and is designed specifically to overcome some problem or create an improvement in local practice. Using mixed methods: DBR involves mixed methods, research tools, and techniques. Involving multiple iterations: the creation and testing of prototypes, iterative refinement, and continuous evolution of the design, as it is tested in authentic practice. Involving a collaborative partnership between researchers and practitioners. The principles are sustained in real-life contexts. This requirement to develop practical design principles is a key strength of DBR. As pointed out (Cole et al., 2005) is the reflexion of the practical nature of DBR and the need for action research to add a "build" phase in which the construction of theories, artifacts, models, and prototypes results in the instantiation, archiving, and distribution of the action research results.

This research adopted an educational design-based research approach for several reasons: fundamentally because the main objective is the design of a framework for the adoption and sustainable use of mobile learning oriented to its practical implementation; other reasons are that is research in real environments; also, because it implies the adoption of technology; it also combines quantitative and qualitative methodologies; it involves a collaborative partnership between researchers and practitioners; its grounded on prior mobile learning frameworks studies; and implies the evolution of design principles, Table 1 summarizes those arguments.

Table 1. Design-based characteristics in this research

DBR MAIN FEATURES	IN THIS RESEARCH
Being situated in a real educational context	Being situated in a real educational context of primary and secondary school in Catalonia
Focusing on the design and testing an artefact/theory	The research aims to develop a mobile learning framework
Using mixed methods	The research is based on quantitative and qualitative methodologies integrated in different approaches such as Technology Acceptance Model (TAM).
Involving multiple iterations	The research includes three interventions
Involving a collaborative partnership between researchers and practitioners	Expert judgement process based on collaborative partnership.

Empirical grounded	The initial framework prototype is based on prior frameworks
Evolution of design principles	The investigation develops a mobile framework and evolves design principles
Practical impact on practice	The model is oriented to be implemented in educational centres

2.2. Phases of the investigation

The phases and chronology that have been followed in this study are based on the different approaches described by Reeves 2006 in relation to DBR in educational technology research: (1) analysis of practical problems by researchers and practitioners in collaboration; (2) development of solutions informed by existing design principles and technological innovations; (3) iterative cycles of testing and refinement of solutions in practice; and (4) reflection of produce “design principles” and enhance solution implementation.

Using the four phases included in the Reeves design, et al., 2007 developed a series of equivalences coordinating each phase with the traditional structures of an investigation. This mapping helps to situate each of the phases concerning paradigms, to identify what elements it includes and to position it within the research. Table 2 shows the phases of design-based research mapped against typical elements of a research proposal according to Herrington et al., (2007).

Table 2. Design-based research equivalences with structures of an investigation (adapted from Herrington et al., 2007)

DBR Phase	ELEMENT
PHASE 1: Analysis of practical problems by researchers and practitioners in collaboration	Statement of the problem. Consultation with researchers and practitioners
	Research questions
	Literature review
PHASE 2: Development of solutions informed by existing design principles and technological innovations	Theoretical framework
	Development of draft principles to guide the design of the intervention
	Description of proposed intervention
PHASE 3: Interactive cycles of testing and refinement of solutions in practice	Implementation of intervention (First iteration)
	Participants; Data Collection; and Data analysis
	Implementation of intervention (Second and further iterations)
	Participants; Data Collection; and Data analysis
PHASE 4: Reflection to produce "design principles" and enhance solution implementation	Design principles
	Designed artefact
	Professional development

Following the DBT phase structure suggested by J. Herrington et al., (2007) the investigation of this thesis has been designed, which is found in section 1.6 of the first chapter.

2.3. Data collection methods

Systematic review

The systematic review of the literature has been the most used approach in this thesis, seven of the nine studies included in this thesis include systematic reviews of the literature. Fink (2005) defined the systematic review of literature as a research literature review “a systematic, explicit, comprehensive, and reproducible method for identifying, evaluating, and synthesizing the existing body of completed and recorded work produced by researchers, scholars, and practitioners” (pp. 3, 17). Okoli (2015) introduced the formal methodology of systematic review of the literature specifically oriented to the research of information systems. And he highlighted that the methodology is applicable in different areas of information systems such as the social sciences.

Okoli (2015) identified three types of literature review. He called the first type

"Theoretical Background" and defined it as the section of a study that provides the theoretical foundations and context of a research question. The second type of systematic review of the literature describes it as the content of a thesis chapter and calls it "thesis literature review". He calls the third type of systematic literature review "standalone literature review". This type of review includes data collection, without analysing them. Table 3 summarizes the studies contained in this thesis that include systematic reviews of the literature, with the classification proposed by Okoli (2015) and the number of studies that each article includes.

Table 3. Classification according to Okoli (2015) of studies that include systematic reviews

CLASSIFICATION/STUDY	n
Theoretical Background	
Study 3. Design principles of mobile learning frameworks	20
Study 4. Planning to implement change. Strategic Pillars to Lead Mobile Learning in the Secondary School Environment	15
Study 6. What factors matter most for mobile learning adoption?	27
Study 8. Cuadro de mando para el seguimiento en la adopción del mobile learning en educación	20
Thesis literature review	
Study 1. A taxonomy of mobile learning based on a systematic review of research publications from 2009 to 2018	25
Study 2. Características, funcionalidades y beneficios de m-learning: revisión sistemática de la literatura	41

The guide for the realization of the literature proposed by Okoli (2015) consists of eight steps structured in four phases, Figure 5 synthesizes these steps, as well as the adaptation of each one in this thesis. In the first planning phase, two steps are developed. First, Identify the Purpose, a first introductory approach where theoretical support is given to the rest of the research. In the articles included in this thesis, this step is in the introduction section. The second step within this first planning phase is very relevant, since it consists of the creation of a protocol with the aim of obtaining an external validation of the rigor of the process. In the case of this thesis, the protocols of each study were repeatedly validated during the different reviews to which the articles were submitted.

The second phase consists of the selection of files, the first step is called apply practical screen and refers to deciding which studies will be part of the review. Selection criteria are established for them that may be content; publication language; Journals; authors; participants or subjects (e.g. educational levels; students); program or intervention; research design or sampling methodology; date of publication; or source. The fourth step included in this phase is Search for Literature, where sources are used applying the search criteria to obtain the studies. Usually in the studies that this thesis contains, this step is referred to as research strategy. Different digital sources such as Web of Science, Scopus and Google scholar have been consulted, these sources have been completed with the review of doctoral thesis, as well as references included in the selected articles. For literature reviews conducted in relation to education, the Web of Science database has been recommended by several previous studies (Fu & Hwang, 2018). During the study selection process, different strategies have been used to refine the search, such as title analysis, abstracts, full review, reference review, following the procedure proposed by Yousra Banoor et al., (2019).

The next stage of this process has the objective of extracting the data necessary for the study and consists of two steps. The first step of this stage and the fifth of the process is data extraction and Okoli (2015) describes it as reviewers systematically take information from each paper to serve as the raw material for the synthesis step (pp. 895). Within this step, a crucial part is the coding of the information to be able to be extracted and analyzed in an orderly and structured way (Elo & Kyngäs, 2008). The seventh step is called Appraise Quality and is intended to evaluate the quality and relevance of the studies included in the systematic review of the literature. For this step, in this thesis, the quality of the sources where the studies and citations have been published has been used, increasingly considered a more relevant indicator to evaluate the quality of research (Luo et al., 2018).

The last stage in this process is called Execution and includes two steps. The first Synthesize studies where the aim is to obtain complete information in a synthesized and orderly way. In some analyses it presents great difficulty since the studies are not homogeneous. It is recommended to map all the information provided in a database that contains all the metadata(Okoli, 2015; Webster & Watson, 2002). For most of the studies included in this thesis that use this methodology, a metadata table has been developed. Appendix 1 contains the link to access the metadata table. The final step in the systematic literature review process is called "write the review" where the findings are explained. In this thesis, the results are found in the seventh chapter.

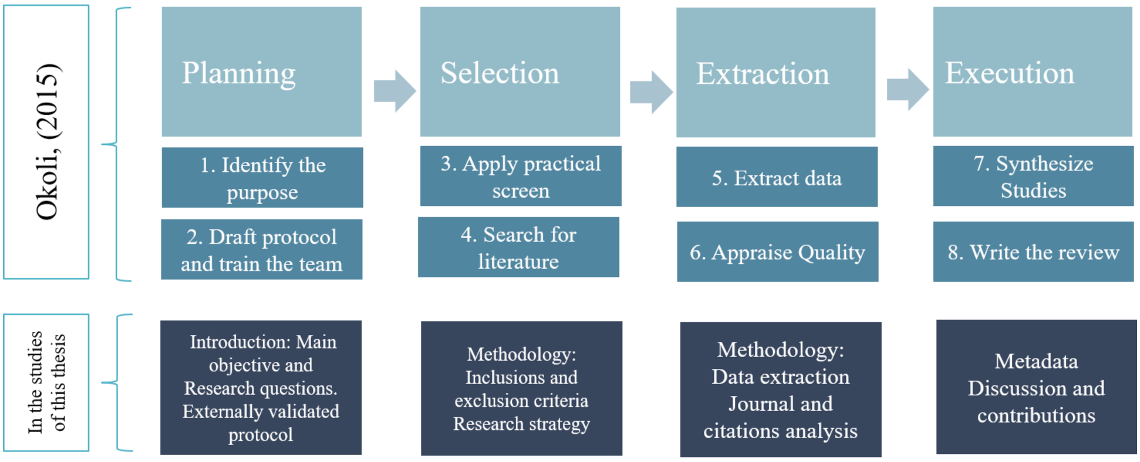


Figure 5. Systematic Review guide (adapted from Okoli, 2015, 885

Expert Judgement

Initially developed in the business field and oriented to decision-making, the judging methodology of experts has been increasingly extended within different fields of research, including education. "Experts are indispensable in modern organizations. They fill gaps in data and in the understanding of existing or missing data. When experts give their opinions in a context of decision-making, these become expert judgements (Benini et al., 2017, p. 1)

The first iteration of this study brought together 7 experts to evaluate the dimensions that most affected the adoption of mobile learning. The process that was followed was that suggested by Benini et al. (2017) which shows the Figure 6. The process of expert judgement (adapted from Benini et al., 2017).

Figure 6. The process of expert judgement (adapted from Benini et al., 2017)

Questionnaire

The process of developing create the questionnaire was adapted from the seven phases process defined by (Cohen et al., 2013) depicted in Figure 7. The population includes 45,000 primary and secondary school teachers in Catalonia. The structure of the questionnaire has been based on the constructs identified during the systematic review, the specific questions of the questionnaire have been added ad hoc. In addition to the sociodemographic questions, most of the questions are Likert type on a 5-point scale that seeks to assess the perceptions and attitudes of teachers in the adoption of mobiles. The questionnaire has been validated by two experts, a pilot test has been conducted and the distribution has been by emailing and social networks. The statistical package SPSS has been used for the analysis of results.

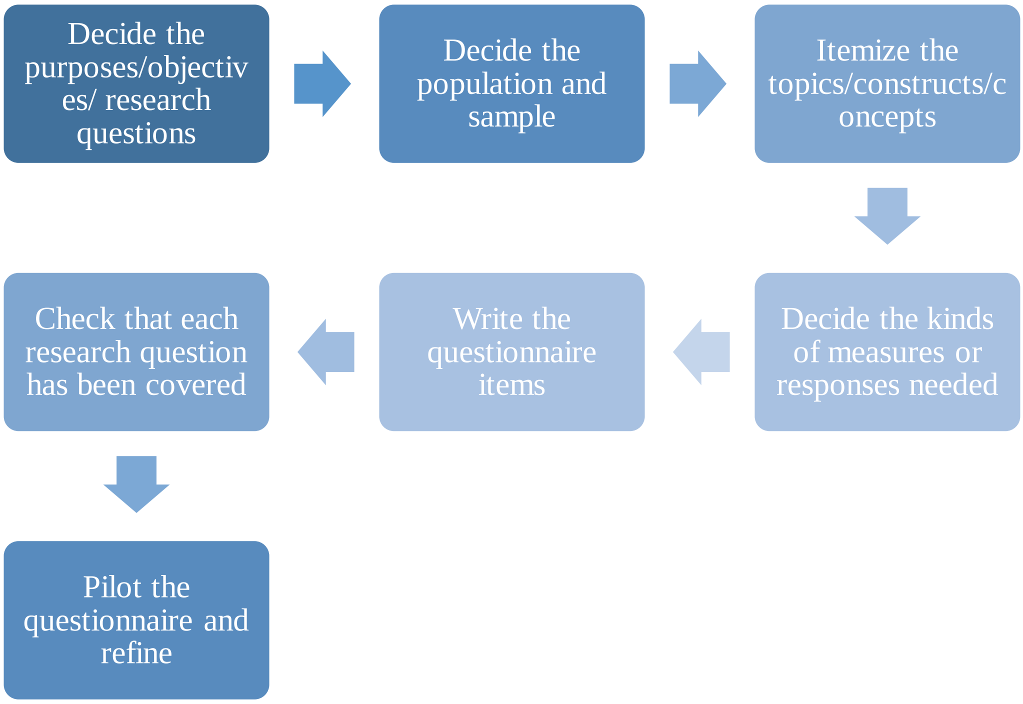


Figure 7. Questionnaire design (Adapted from Cohen et al., 2013)

CHAPTER 3

DESIGN CYCLE ONE: ANALYSIS OF PRACTICAL PROBLEMS

This chapter develops the first phase of DBR consisting of contextualizing and identifying practical problems (McKenney & Reeves, 2018). This chapter aims to answer the first two research questions of this thesis: RQ1. What is the current state of mobile learning research? And RQ2. What are the main characteristics and functionalities of mobile learning?

Two studies are part of this first cycle, the first study: "A taxonomy of mobile learning based on a systematic review" is focused on identifying the current state of research in mobile learning, responding to the first of the research questions in this thesis. The second study: "Characteristics, functionalities and benefits of mobile learning: systematic review of the literature", identifies and analyzes the main characteristics and functionalities of mobile learning, as well as its pedagogical benefits.

3.1. Study 1: "A taxonomy of mobile learning based on a systematic review" [1]

3.1.1. Introduction

This study seeks to deepen the understanding of existing mobile learning research, summarize the relevant knowledge, and identify research gaps. This study is based on a systematic review of relevant studies conducted between 2009 and 2018; the final pool of studies comprised 25 studies, representing a total of 1828 original academic publications. A taxonomy was proposed based on 13 taxonomies, which were grouped into five domains: bibliometric statistics; research purposes; demographics and context; methodologies; and outcomes. The findings revealed the following: the number of articles published has increased over the last years, with significant contributions from Asia; most studies feature positive outcomes; the main focus is on learning effectiveness; the majority of the target sample comprises students, and the environment is hybrid, with a tendency to be informal; and mixed research methodologies are the common trend. The results also revealed a lack of current research in the field of strategies and frameworks, a common thread among all these studies.

One of the main challenges to conducting a rigorous analysis is the diversity and lack of consistency in the classification and methodological coding of the main aspects of the field. Up to 99 different categories used by leading authors in the field of mobile learning have been identified.

Purposes of this study

This study attempts to investigate the existing mobile learning research, summarize, and organize the relevant knowledge, and to consolidate the basis for its adoption and sustainable

[1] Moya, S., & Camacho, M. (2020a). A taxonomy of Mobile Learning based on Systematic Review. International Journal of Mobile Learning and Organization, 14(4), 425–455. https://doi.org/10.1504/IJMLO.2020.10030686

development. Specifically, the present review was guided by the following research questions, all of them considering the 2009-2018 period:

RQ1 Why is mobile learning research relevant? In moderating mobile learning, what are the main bibliometrics and statistics, including the development trend of the number of academic publications, sources of academic publications, citations, and geographical distribution.

RQ2. What knowledge has been investigated? What are the dominant research purposes related to mobile learning?

RQ3. Who is and where is the target? What are the key research demographics and context: sample type; educational levels; sample size; learning domains; learning context; and devices used?

RQ4. How has the research been conducted? What are the major research designs and methodologies in the mobile learning field?

RQ5. What are the main outcomes in the studies of mobile learning?

3.1.2. Method

Research design

A systematic review (Hemingway & Brereton, 2009) approach was performed in this study to answer the five research questions directing this study, with the goals of providing an impartial synthesis, summarizing and generalizing the relevant knowledge trends, as well as identifying and prospecting for patterns, gaps and interpreting the findings.

Inclusion and exclusion criteria

The inclusion and exclusion criteria used to filter academic publications gathered from digital databases were defined based on the research questions guiding this research:

(1) Mobile learning, ubiquitous learning, and Mlearning or blended learning were among the key variables of the study. The studies must have been published between 2009–2018.

(2) The study design was quantitative (descriptive, comparative, quasi-experimental, experimental), and the methodology comprised a meta-analysis or systematic review.

(3) The outcomes were robust, clearly defined, scientifically traceable, plausible, and relevant.

(4) The studies must have been published in a peer-reviewed, internationally oriented journal.

(5) Studies were excluded based on the following criteria: 1) they did not focus on learning, education or adopting educational purposes, 2) the articles were based on original research.

Search strategy and retrieval of studies

The search of the literature was based on a concept-centric approach (Okoli, 2015; Okoli & Schabram, 2010; Webster & Watson, 2002). In the search of the literature in the database, the expressions ("mobile learning" OR "ubiquitous learning" OR "blended learning" OR "M-learning" OR "B-learning" OR "mobile devices") AND ("systematic review" OR "meta-analysis" OR "trends") were used as keywords.

The research process initially yielded 599 publications. Based on titles, 48 were filtered; in reading the abstracts, keywords were re-vised and refined. The article grouping was adjusted and summarized in meta-data, and based on the inclusion and exclusion criteria, a concept matrix was developed for the selected studies. Appendix 1 contains the link to access the metadata. A total of 30 full texts were screened by the two authors, and based on the criteria, 25 were identified as eligible for the review and were comprehensively analysed. The differences in the interpretation were resolved upon discussion. Figure 8 shows the data search and collection process.

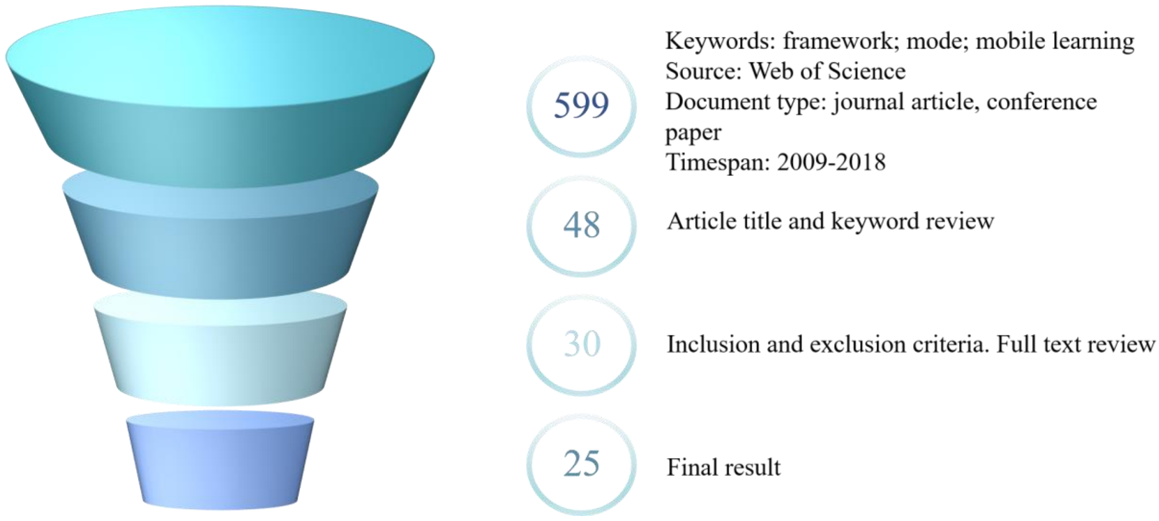


Figure 8. Diagram of the literature search process

The final pool of studies comprised 25 studies, representing a total of 1828 original academic publications.

3.1.3. Results

Taxonomies and coding

Based on the process described in section 2.1, the third step in concluding a systematic review is to identify the main taxonomies by which to structure, organize, and codify the research. For that purpose, a content analysis methodology was used. In the analysis of documents, content analysis is a method that enables the researcher to test theoretical issues to enhance the understanding of the data (Elo & Kyngäs, 2008). Content analysis can use a mix of quantitative and qualitative methods so that a combination of bibliometric and categorical data can be used to reveal trends (Wu et al., 2012).

For addressing the advancement of mobile learning, all the selected studies focused on a particular set of issues by using a wide variety of names: categories, dimensions, super dimensions, subdimensions, variables, components, and features. Combining all 25 studies, the resulting number of categories analysed was 99. The 25 studies included in this research analysed a mean of 7.32 different categories, ranging from 2 to 12 categories. Only one study analysed two categories (Alrasheedi & Capretz, 2015), and three studies analysed 12 categories (Krull & Duart, 2017; Zheng et al., 2018). The results of the distribution analysis showed a high probability density around the mean number of categories 7.32. The standard deviation was 2.85. Figure 9 shows the distribution and the mean of the categories included in the analysed studies.

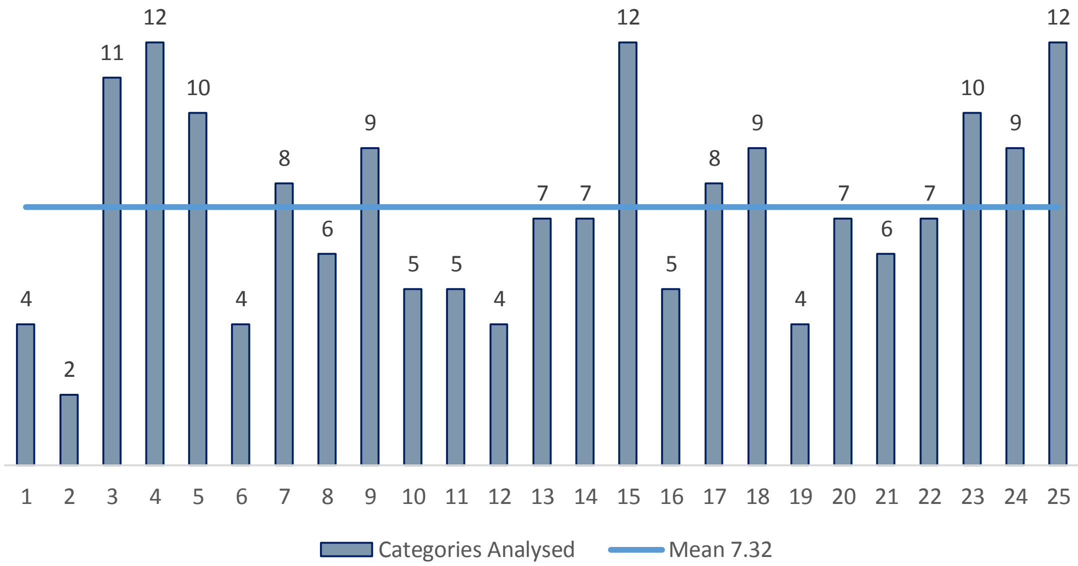


Figure 9. Distribution of the number of categories analysed in the mobile learning research from 2009 to 2018

Figure 10 shows the sample size of the 25 studies included in this research. There is no significant correlation between the size of the original sample of the studies included in this research and the number of categories; the overall correlation coefficient, r, was 0.21.

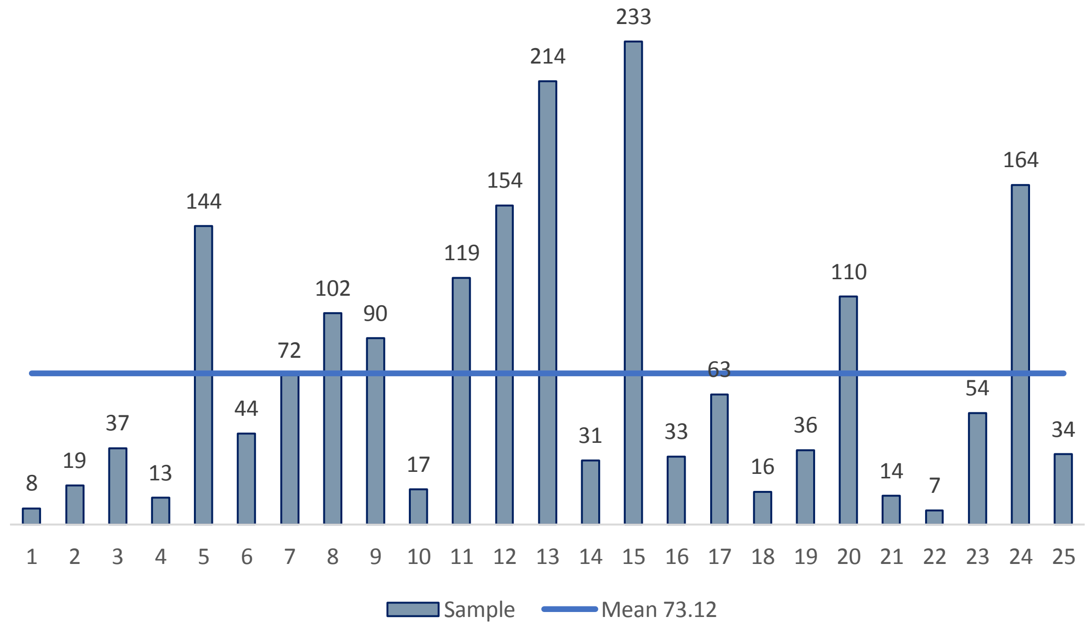


Figure 10. Distribution of the sample size in mobile learning research from 2009 to 2018

The number of categories analysed over the years has been significantly stable. The correlation between the number of categories and the number of years has not been found, as r = 0.28.

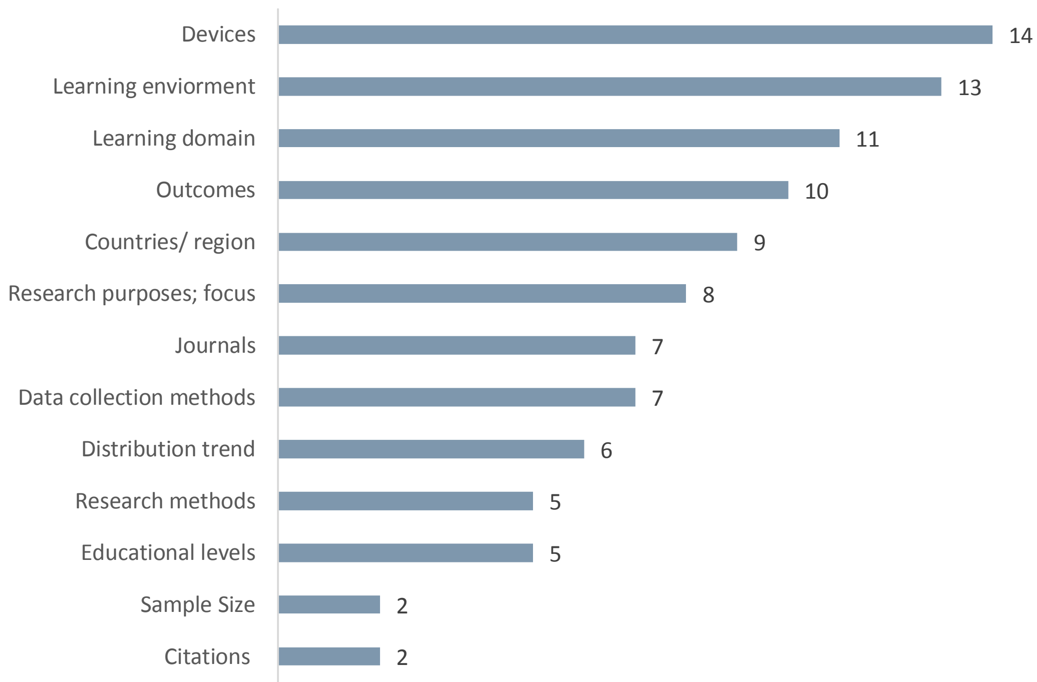
Based on the contents of each study, the original 99 categories were analysed, filtered, and assembled into thirteen categories. Table 4 shows the categorization of the original items analysed in the studies.

Table 4. List of categories included in the mobile learning research from 2009 to 2018

CATEGORY	ORIGINAL EXTRACTS	# ST	STUDIES
Citations	Citations	2	(Bhat & Al Saleh, 2015; Wu et al., 2012)
Countries/ region	Countries; Region; Country context; Geographical spread; World region	9	(Chee et al., 2017; Hwang & Tsai, 2011; Kaliisa & Picard, 2017; Krull & Duart, 2017; M. Liu et al., 2014; Virtanen et al., 2018)
Data collection methods	Data sources; Data Collection	7	(Cheung & Hew, 2009; Crompton & Burke, 2018; Kaliisa & Picard, 2017; Krull & Duart, 2017; Virtanen et al., 2018; Wu et al., 2012; Zheng et al., 2018)
Devices	Types of mobile devices; Technology used; device used; Mobile handheld devices; Mobile devices adopted; Hardware	14	(Baran, 2014; Bhat & Al Saleh, 2015; Chee et al., 2017; Cheung & Hew, 2009; Crompton & Burke, 2018; Fu & Hwang, 2018; Kaliisa & Picard, 2017; Krull & Duart, 2017; M. Liu et al., 2014; Y. T. Sung et al., 2016; Tingir et al., 2017; Wu et al., 2012)
Distribution trend	Trends in m-learning; distribution across years; distribution status; trends in m-learning; number of articles; growth of m-learning research; histogram; distribution by year	6	(Chee et al., 2017; J.-L. Hung & Zhang, 2012; Hwang & Tsai, 2011; M. Liu et al., 2014; Y. T. Sung et al., 2016; Wu et al., 2012)
Educational levels	Educationall levels; Learning Stages; Participants; Subjects; Sample Institution; Learning stage; grade level; Subjects; Sample Groups; Population Groups; Participants	5	(Chee et al., 2017; Crompton & Burke, 2018; Fu & Hwang, 2018; Hwang & Tsai, 2011; Krull & Duart, 2017)
Journals	Periodic journal contribution; rank and title of the journal; prolific journals; major research journals; well-recognized journals; distribution of journals; journal list (in frequency order)	7	(Chee et al., 2017; Crompton & Burke, 2018; J.-L. Hung & Zhang, 2012; Hwang & Tsai, 2011; Hwang & Wu, 2014; Krull & Duart, 2017; M. Liu et al., 2014)
Learning domain	Subject Domain; Learning Domain; Subject Matter Domain; Learning subjects; Academic Disciplines; Subject Area; Disciplines and Courses	11	(Baran, 2014; Chee et al., 2017; Crompton & Burke, 2018; Fu & Hwang, 2018; Hwang & Tsai, 2011; Hwang & Wu, 2014; Krull & Duart, 2017; Y. T. Sung et al., 2016; Tingir et al., 2017; Wu et al., 2012)
Learning environment	Educational context; sample group; environments of mobile learning applications; situated action context; research settings	13	(Bhat & Al Saleh, 2015; Chee et al., 2017; Crompton & Burke, 2018; Frohberg et al., 2009b; Fu & Hwang, 2018; Krull & Duart, 2017; Y. T. Sung et al., 2016; Virtanen et al., 2018; Wu et al., 2012; Zheng et al., 2018)
Outcomes	Learning outcome knowledge and satisfaction; Measured outcomes	10	(Bhat & Al Saleh, 2015; Chee et al., 2017; Crompton & Burke, 2018; Hwang & Wu, 2014; M. Liu et al., 2014; Mahdi, 2018; Pimmer et al., 2016; Y. T. Sung et al., 2016; Wu et al., 2012; Zheng et al., 2018)

Research methods	Methodology; Method; Research design; Research methodology; Design; Study designs	5	(Chee et al., 2017; Fu & Hwang, 2018; Kaliisa & Picard, 2017; Krull & Duart, 2017; Zheng et al., 2018)
Research purposes; focus	Research Purposes; Focus	8	(Al-Zahrani & Laxman, 2016; Chee et al., 2017; Cheung & Hew, 2009; Crompton & Burke, 2018; Fu & Hwang, 2018; J.-L. Hung & Zhang, 2012; Krull & Duart, 2017; Wu et al., 2012)
Sample size	Sample size, group size	2	(Fu & Hwang, 2018; Zheng et al., 2018)

The learning environment and devices are the categories most studied, while citations and the sample size the ones less analysed. Figure 11 depicts the number of articles that



comprised each of the thirteen categories identified in this study.

Figure 11. Distribution of taxonomies analysed in the mobile learning research from 2009 to 2018

Based on the research questions that guided this study, the above categories were organized under the following higher dimensions: bibliometrics, research purposes, context, methodology and outcomes. Figure 12 shows the list of main analysed mobile learning categories, grouped in five dimensions.

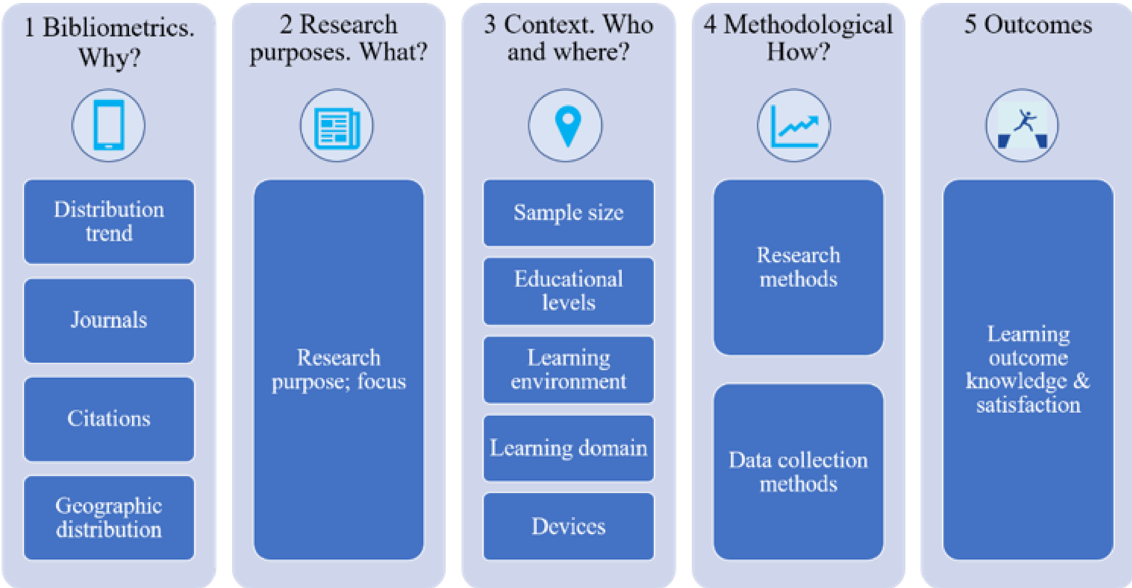


Figure 12. Taxonomies analysed in the mobile learning research from 2009 to 2018

For each of the thirteen categories, coding was assigned based on the 25 studies included in this research. The next sections of the paper present the fourth phase of the systematic review: guided by the taxonomies described above, a statistical analysis was conducted.

Bibliometrics

A bibliometric analysis is a method to evaluate scientific research literature by measuring certain indicators (Thelwall, 2008). It uses quantitative statistics to summarize publication information.

Distribution trend

Erford, Savin-Murphy, and Butler (2010) pointed out that trend analysis can show the periodic discussion taking place in a knowledge discipline. Figure 13 shows the distribution of the research studies selected. It was found that from 2009 to 2018, the number of research studies had significantly increased. This finding is consistent with the conclusions of all the 6 studies discussing this trend (Baran, 2014; Chkee et al., 2017; Hwang & Wu, 2014; Krull & Duart, 2017). The growth is exponential and has been higher in recent years.

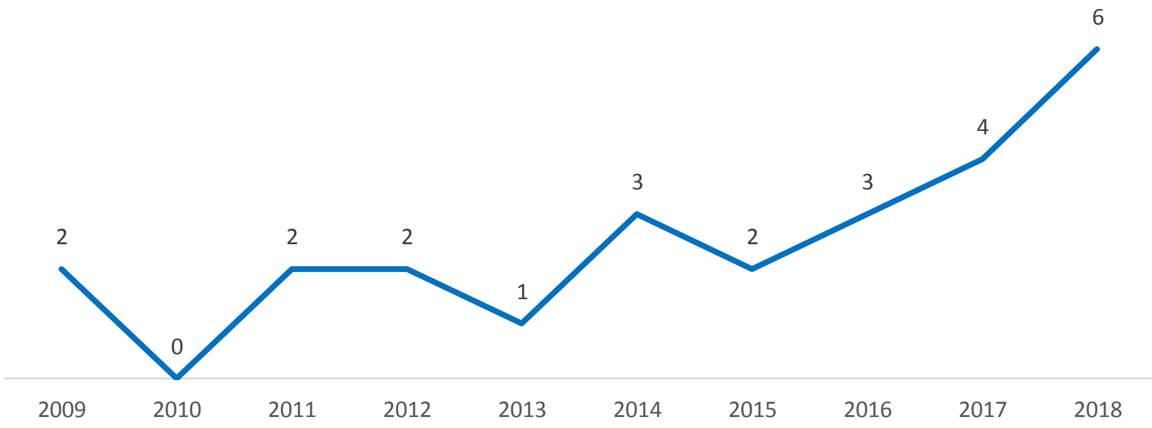


Figure 13. Distribution trend of mobile learning research from 2009 to 2018

Journal contribution to mobile learning

This study represented a wide range of journals developed and developing mobile learning content. A total of 16 different journals published the 25 selected studies. The conclusions of the top 6 journals are consistent with those of prior studies (Chee et al., 2017; Crompton & Burke, 2018; J.-L. Hung & Zhang, 2012; Hwang & Tsai, 2011; Hwang & Wu, 2014; Krull & Duart, 2017; M. Liu et al., 2014). Table 5 depicted the journals contributing the most articles towards mobile learning.

Table 5. Distribution of journals of studies included in this research

JOURNAL	FREQUENCY
Computers & Education	5
Journal of Educational Technology & Society	2
Journal of Computer Assisted Learning	2
British Journal of Educational Technology	2
Turkish Online Journal of Educational Technology - TOJET	2
International Journal of Mobile Learning and Organisation	2
The International Review of Research in Open and Distributed Learning	1
Computers in Human Behaviour	1
Education and Information Technologies	1

Australasian Journal of Educational Technology	1
Journal of Research on Technology in Education	1
Canadian Journal of Learning and Technology / La revue canadienne de l'apprentissage et de la technologie	1
The Journal of Technology Studies	1
Journal of Computing in Higher Education	1
International Journal of Computer Applications	1
Journal of Educational Computing Research	1
Total	25

Citations

Even though only two studies in the systematic review include citations as the variable to consider (Bhat & Al Saleh, 2015; Wu et al., 2012), citation count is an important indicator for measuring research outputs (Luo et al., 2018).

With a boost in the number of research publications in the past years, an increasing number of impact indicators have been developed to facilitate the process of research evaluation. The more frequently cited articles are usually those that receive greater recognition by others in related fields. Citation counts, however, have become one of the most widely acknowledged metrics to assess research quality, in spite of some controversial drawbacks (Leydesdorff & Shin, 2011; Thelwall, 2016). Most other recognized indicators, such as the h-index for researchers, the Journal Impact Factor (JIF), and the SCImago Journal Rank (SJR) for journals, are also intrinsically based on citation counts (Luo et al., 2018). Citation counts of the 25 studies were gathered from Google Scholar (as on July 2nd, 2018) and are shown in table 6.

Table 6. Citation studies in google scholar as the record of July 2nd, 2018

STUDY	CITATIONS	STUDY	CITATIONS
(Al-Zahrani & Laxman, 2016)	13	(Hwang, 2014)	14
(Alrasheedi & Capretz, 2015)	24	(Krull & Duart, 2017)	3
(Baran, 2014)	193	(Kukulska-Hulme & Viberg, 2018)	271
(Bhat & Al Saleh, 2015)	7	(M. Liu et al., 2014)	79
(Chee et al., 2017)	12	(Mahdi, 2018)	2
(Cheung & Hew, 2009)	157	(Pimmer et al., 2016)	51

(Crompton & Burke, 2018)	49	(Y. T. Sung et al., 2016)	206
(Frohberg et al., 2009a)	380	(Tingir et al., 2017)	6
(Fu & Hwang, 2018)	2	(Virtanen et al., 2018)	2
(Hsu & Ching, 2015)	25	(Wong & Looi, 2011)	363
(J.-L. Hung & Zhang, 2012)	128	(Wu et al., 2012)	589
(Hwang & Tsai, 2011)	348	(Zheng et al., 2018)	1
(Hwang & Wu, 2014)	121		

Wu et al. (2012) categorized highly cited articles as those with 13 or more cites. Based on this scale, 17 out of the 25 articles included in the study fall into this category. Given their recent publication, the 5 studies from 2018, could be expected to have the potential for a high citation count in the future. To complete the analysis, the first author's h-index was also analysed. The h-index mean for the 25 studies was 11. Figure 14 displays the h-indexes for the first authors of the 25 studies.

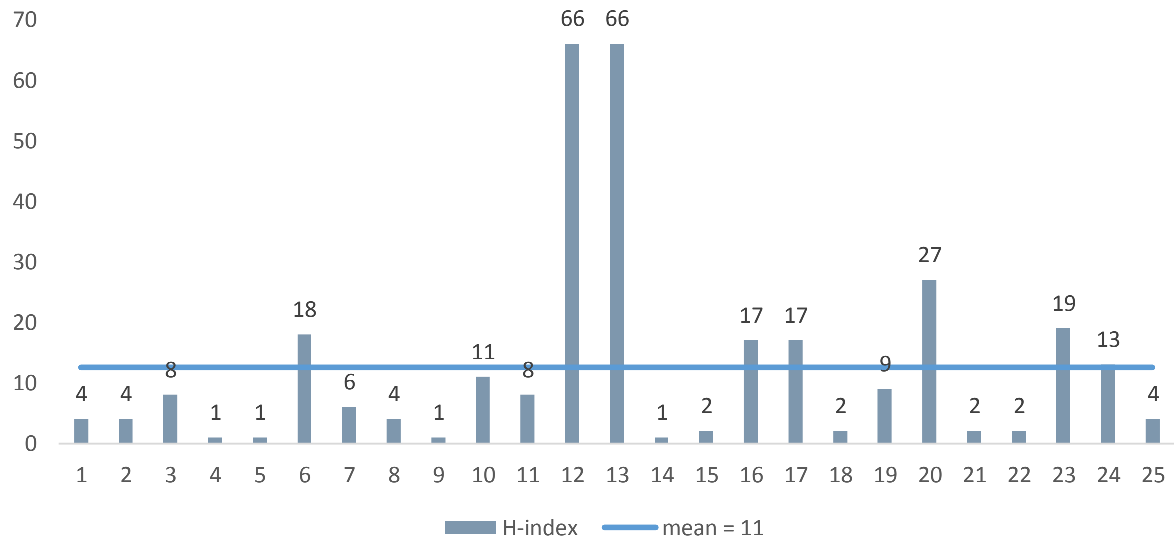


Figure 14. First authors' H-index. Web of Science as the record of July 2nd, 2018

Geographical distribution

The country categorization was based on the researcher's affiliation. A total of 9 different countries were represented in the 25 articles included in this study. The citation was included in the analysis to add perspective on the relevance associated with the number of articles. As shown in Table 7, representing the continent with which researchers in 8 of the 9 studies were affiliated, Asia is the leading continent in terms of the number of articles published and citations. (K. N. Chee et al., 2017; Crompton & Burke, 2018; H.-C. Hung & Young, 2015; Hwang & Tsai, 2011; Krull & Duart, 2017; Liu et al., 2014; Virtanen et al., 2018). Regarding mobile learning research, Taiwan has become the top country in terms of the number of articles and citations, highlighting the contribution of Hwang, G. J.

Table 7.Mobile learning research from 2009 to 2010: geographical distribution by the number of articles, citations, and average publication year

STUDY	# ARTICLES	AGGREGATE CITATIONS	AVERAGE YEAR
Asia	10	1,812	2,014
Taiwan	4	1,264	2,013
Singapore	2	520	2,010
China	2	3	2,018
India	1	13	2,013
Malesia	1	12	2,017
North America	6	311	2,015
USA	5	287	2,015
Canada	1	24	2,016
Europe	6	630	2,015
Switzerland	2	431	2,013
Finland	1	2	2,018
Spain	1	3	2,017
Turkey	1	193	2,014
UK	1	1	2,018
Middle East	2	9	2,017
Saudi Arabia	2	9	2,017
Australia	1	14	2,017
Australia	1	14	2,017
Total	**25**	**2,776**	**2,015**

Research purposes

The research purposes of 8 studies were included in our analysis (Al-Zahrani & Laxman, 2016; alZahir, 2011; Chee et al., 2017; Cheung & Hew, 2009; Crompton & Burke, 2018; Fu & Hwang, 2018; Krull & Duart, 2017; Wu et al., 2012).

The variety of the codes used in the coding scheme is significant. For the purposes of this research, (Krull & Duart, 2017; Wu et al., 2012) the coding scheme was adapted to fit all the 49 different research purposes codes identified into the following five categories:

(1) Evaluation of effectiveness, focusing on the investigation of whether mobile devices can improve or enhance student learning.

(2) Affective domain, including the identification of factors such as student motivation, beliefs, attitudes, perceptions, and values.

(3) Design of systems and tools, emphasizing the development and presentation of solutions,

(4) Pedagogical frameworks, comprising studies on the development of learning frameworks and strategies promoting, creating, and adapting pedagogical approaches.

(5) Attributes, including affordances, usability, demographics, and trends.

(6) After developing the coding scheme, two coders started to code independently. To ensure their consistency, two strategies were used to solve differences: think pair share and group discussions Table 8 shows the correlation between the original studies' codes and the coding scheme.

Table 8. Mobile learning research purpose different codes from 2009 to 2010

CATEGORY	ORIGINAL CODE AND STUDY
Evaluation of effectiveness	Correlation or Cause-and-effect Analysis (Fu & Hwang, 2018); Evaluate effectiveness (Krull & Duart, 2017); Learning outcomes (Cheung & Hew, 2009); Learning performance (Fu & Hwang, 2018); Outcome (Al-Zahrani & Laxman, 2016); Student achievement (Crompton & Burke, 2018); Effectiveness, Evaluation and Personalization System (J.-L. Hung & Zhang, 2012); Evaluating the effects (Chee et al., 2017); Evaluate effectiveness (Wu et al., 2012);
Affective domain	Acceptance (perception), (Al-Zahrani & Laxman, 2016); Acceptance and Issues (J.-L. Hung & Zhang, 2012); Affective domain (Krull & Duart, 2017); Affective domain (Wu et al., 2012); Attitude, Motivation or Anticipation of effort, (Fu & Hwang, 2018); Collaboration and communication, (Fu & Hwang, 2018); Elicit perceptions of M-Learning, (Chee et al., 2017); Evaluate or explore the factors towards M-Learning (Chee et al., 2017); Factors that influence the use of mobile learning (Crompton & Burke, 2018); Learning behaviour or Engagement (Fu & Hwang, 2018); Level of anxiety (Fu & Hwang, 2018); Opinion of Learner or Learning perception (Fu & Hwang, 2018); Satisfaction or Interest (Fu & Hwang, 2018); Students' perceptions, (Crompton & Burke, 2018); User attitudes (perceptions) (Cheung & Hew, 2009)
Design of systems and tools	Design systems (Krull & Duart, 2017); Designing a mobile system for learning (Chee et al., 2017); Specific mobile learning system or applications (Device/App) (Crompton & Burke, 2018); Design systems (Wu et al., 2012)
Pedagogical frameworks and strategies	Cognitive load (Fu & Hwang, 2018); Develop Theory (Krull & Duart, 2017); Strategies and frameworks (J.-L. Hung & Zhang, 2012); Viability of mobile devices as an assessment too (Cheung & Hew, 2009); Type of pedagogy used in mobile learning (Crompton & Burke, 2018)
Attributes	Evaluate the Influence of Learning Characteristics (Krull & Duart, 2017); Evaluate the Influence of Learning Characteristics (Wu et al., 2012); Explore Potential (Krull & Duart, 2017); Mobile learning case studies (J.-L. Hung & Zhang, 2012); Readiness (usability) and outcome (Al-Zahrani & Laxman, 2016); Self-efficacy, Confidence or Anticipation performance (Fu & Hwang, 2018); Usage profile (Cheung & Hew, 2009); Research Trends (Al-Zahrani & Laxman, 2016)

Based on this classification, Figure15 shows that the most common research purpose is the evaluation of effectiveness (33%), followed by affective domain (24.5%), affordances, uses and trends (22%), design, systems and tools (12.4%), and finally pedagogical frameworks (8.0%).

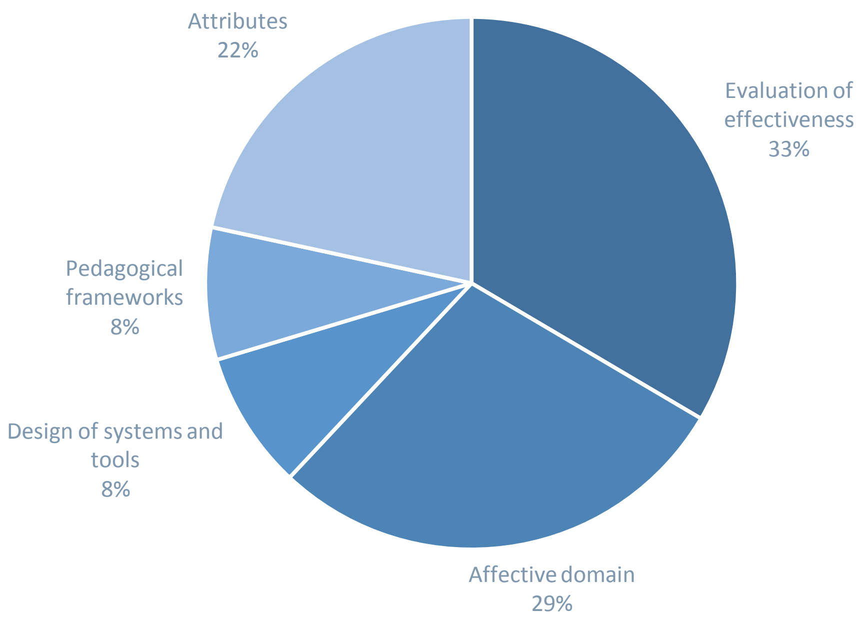


Figure 15. Mobile learning research purposes from 2009 to 2010

Although it would be much more interesting to focus this study on a review of the literature on the use of different mobile learning strategies (Hwang et al., 2015), we unfortunately do not have enough resources to carry out the analysis with the methodology used.

Regarding the research purpose category, our results are consistent with other studies conducted in this type of research (Bhat & Al Saleh, 2015; Boticki et al., 2011; Frohberg et al., 2009a; Hsu & Ching, 2015; Kaliisa & Picard, 2017; M. Liu et al., 2014; Pimmer et al., 2016; Tingir et al., 2017; Virtanen et al., 2018).

Demographics and context

In the present study, the demographics and context of the selected 25 studies were analysed in terms of five categories: sample size and range; sample type and educational level; learning environment; learning domain; and device.

Sample size and range

Two subcategories were included in this category, namely, sample size and the period analysed. The mean sample size of the studies included in this research is 73.12 publications per study, with a standard deviation of 65.76. The variation over the years is not significant, and the Pearson correlation coefficient p is 0.21.

In relation to the period for each article, the mean range of years across articles is 8.88 years per study, with a standard deviation of 3.822. The trend of the variation over the years is not significant. For the correlation coefficient, r =+0.15.Figure 16 shows the evolution of the range of years included in the studies across the years.

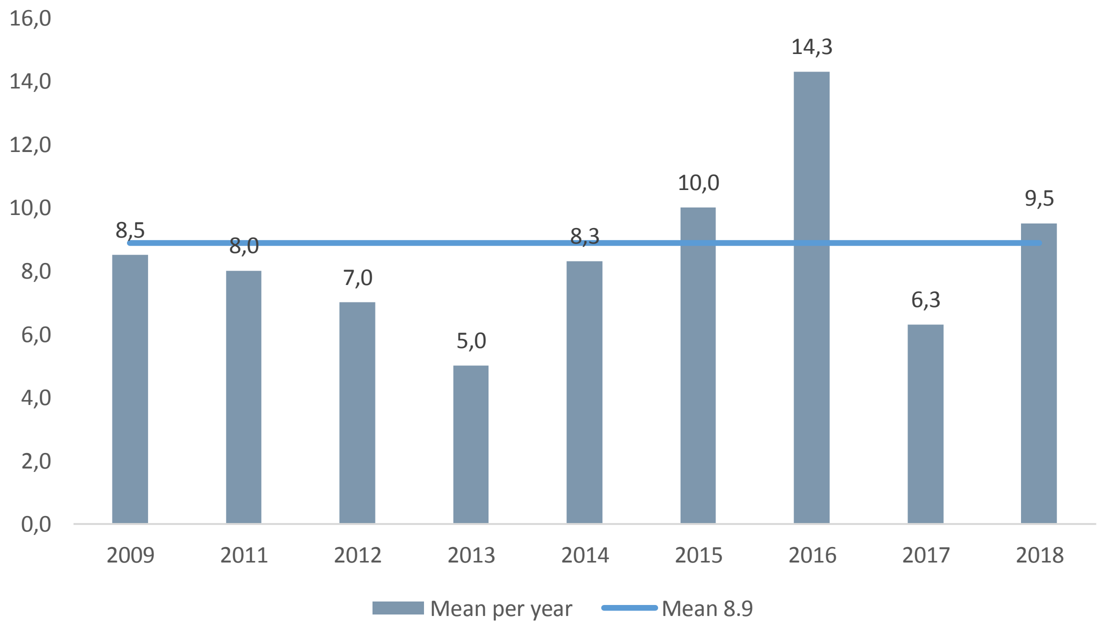


Figure 16. Histogram and mean of the number of years analysed in mobile learning research

In terms of original studies, only two studies analysed the sample size in their articles, (Fu & Hwang, 2018; Zheng et al., 2018). Both coded the groups into a small, medium, and large sample size (using different ranges) and concluded that most studies adopted a medium sample size.

Sample type and educational levels

The sample type refers to the educational stakeholders comprising the researched target group for mobile learning. Five studies reported results in this field Table 9 shows the different names for this field and the codes given by each study. To this study, the sample type was coded as follows: students, faculty, or teachers, and other or non-specified.

Table 9. Sample target names and codes studied in mobile learning from 2009 to 2018

STUDY	CATEGORY NAME	STUDY CODE	PROPOSED CODE
(Fu & Hwang, 2018)	Participants	Non-specified	Other
		Students	Learners
		Teachers	Educator
		Working adults	Other
(Krull & Duart, 2017)	Population groups	Faculty	Educator
		Other	Other
		Students	Learners
(Hwang & Tsai, 2011)	Sample Group	Non-specified	Other
		Students	Learners
		Teachers	Educator
		Working adults	Other
(Chee et al., 2017)	Sample individual	Elementary or Primary Student	Educator
		Elementary or Primary Teacher	Educator
		High School or Secondary Students	Learners
		High School or Secondary Teacher	Educator
		Higher education Instructor	Educator
		Higher Education Student	Learners
(Crompton & Burke, 2018)	Educations levels	Faculty	Educator
		Graduate	Learners
		Undergraduate	Learners

Based on the above codes, the five studies' results were combined. Due to the lack of availability of some original databases, the studies' overlaps could not be adjusted; consequently, the weighted results could not be shown. Table10 demonstrates the results of the analysis by sample type.

Table 10. Sample type in mobile learning research from 2009 to 2018

STUDY	SAMPLE SIZE	LEARNER	EDUCATOR	OTHER

(Chee et al., 2017)	144	78%	22%	0%
(Crompton & Burke, 2018)	72	98%	2%	0%
(Fu & Hwang, 2018)	90	91%	4%	5%
(Hwang & Tsai, 2011)	154	76%	4%	20%
(Krull & Duart, 2017)	233	78%	10%	12%

It was found that most studies were aimed at students (above 76%). Students were the most often researched group members for mobile learning studies. With one exception (Chee et al., 2017), few studies targeted faculty or teachers (less than 10%).

Regarding educational levels, the studies were grouped into four major categories: higher education, high or secondary, elementary, and other or not specified. A total of 8 studies analysed educational levels. Table11 shows the different names for this field and the codes given by each study.

Table 11. Names and Codes of the Educational level studied in mobile learning from 2009 to 2018

STUDY	CATEGORY NAME	STUDY CODE	PROPOSED CODE
(Wu et al., 2012)	Education Contexts	Elementary	Elementary
		Higher education	Higher education
		High or secondary	High or secondary
(Tingir et al., 2017)	Grade Level	Elementary	Elementary
		High	High or secondary
		Middle	Elementary
(M. Liu et al., 2014)	Grade-level distribution (k-12)	Elementary	Elementary
		High school	High or secondary
		Middle school	Elementary
(Mahdi, 2018)	Level	Elementary	Elementary
		High school	High or secondary
		University	Higher education
(Fu & Hwang, 2018)	Participants	Elementary students	Elementary
		High school students	High or secondary
		Higher education	Higher education
(Y. T. Sung et al., 2016)	Participants	Adults	Other/Not specific
		College	Higher education
		Elementary school	Elementary
		High school	High or secondary
		Kindergarten	Elementary
		Middle school	Elementary

		Mixed	Other/Not specific
(Hwang & Tsai, 2011)	Sample Group	Elementary students	Elementary
		High school students	High or secondary
		Higher education	Higher education
(Zheng et al., 2018)	Sample groups	Elementary school	Elementary
		High school	High or secondary
		Higher education	Higher education
(Chee et al., 2017)	Sample Institution	Elementary or primary	Elementary
		High or secondary	High or secondary
		Higher education	Higher education
		Not Specific	Other/Not specific
		Working adult	Other/Not specific

Based on the above categories, the results of the nine studies covering educational level are shown in Table 12. For the same reasons described previously, the weighted results cannot be shown. However, we could reasonably conclude that higher education is the level where more research has been conducted and that high school or secondary schools comprise the levels with the lowest number of studies. This fact is confirmed in the two studies focusing on K through 12 students and in which the focus on elementary school students is significantly higher than that on high school or secondary school students. “There is tremendous room for research to be carried out for other samples such as secondary or high school and working adults” (Chee et al., 2017, p. 11).

Table 12. Distribution of educational levels in mobile learning from 2009 to 2018

STUDY	SAMPLE SIZE	ELEMENTARY	HIGH OR SECONDARY	HIGHER EDUCATION	OTHER/ NON-SPECIFIED
(Chee et al., 2017)	144	21%	6%	36%	18%
(Fu & Hwang, 2018)	90	27%	17%	55%	0%
(Hwang & Tsai, 2011)	154	27%	11%	62%	0%
(M. Liu et al., 2014)	63	69%	21%	*	10%
(Mahdi, 2018)	16	6%	25%	69%	0%
(Y. T. Sung et al., 2016)	110	15%	9%	38%	4%
(Tingir et al., 2017)	14	71%	29%	*	0%
(Wu et al., 2012)	164	22%	4%	74%	0%
(Zheng et al., 2018)	34	65%	6%	29%	0%

*Studies focused on k12 students.

Learning environment

The portability of mobile devices enables the use of mobile learning in authentic settings outside the classroom and the engagement in content learning within a specific context. Outside classroom education has been associated with informal learning; however, Chee et al. (2017) found that boundaries between formal and informal learning spaces were blurred when students had access to mobile technologies. "Notions of formal and informal learning are, however, very vague and need to be clarified in this context" (Pimmer et al., 2016). Moreover, the debate is moving towards physical and digital or virtual contexts (Wong & Looi, 2011).

Ten studies analysed the learning environments or contexts, providing different category names for which codes were assigned. The categories were grouped into three codes: formal, informal and both or non-specified. Table 13 displays the different category names and the codes used in the studies analysed.

Table 13. Learning environment category names and codes in mobile learning research

STUDY	CATEGORY NAME	STUDY CODE	PROPOSED CODE
(Bhat & Al Saleh, 2015)	Educational Contexts	Non-Informal	Non-Informal
		Informal	Informal
		Formal	Formal
(Chee et al., 2017)	Educational Contexts	Formal and Informal	Formal and Informal
		Informal Learning	Informal Learning
		Formal Learning	Formal Learning
(Crompton & Burke, 2018)	Educational Contexts	Both	Both
		Informal	Informal
		Formal	Formal
(Frohberg et al., 2009a)	Context	Independent Context	Independent Context
		Physical context and socializing context	Physical context and socializing context
		Formalizing context	Formalizing context
(Fu & Hwang,	Learning	Others and non-specified	Others and non-specified

2018)	environment	School Campus; Museum library, ecological area, and science park	School Campus; Museum library, ecological area, and science park
		Classroom or laboratory	Classroom or laboratory
(Hwang & Wu, 2014)	Contexts	Both indoor and outdoor	Both indoor and outdoor
		Outdoor	Outdoor
		Indoor	Indoor
(Krull & Duart, 2017)	Research Settings	Not Specific	Not Specific
		Out of Class; Field	Out of Class; Field
		In Class	In Class
(Y. T. Sung et al., 2016)	Implementation setting	Not mentioned and Unrestricted	Not mentioned and Unrestricted
		Informal settings	Informal settings
		Formal settings	Formal settings
(Wu et al., 2012)	Educational Contexts	Non-formal; N/A	Non-formal; N/A
		Informal	Informal
		Formal	Formal
(Zheng et al., 2018)	Intervention settings	Mixed	Mixed
		Informal settings	Informal settings
		Formal settings	Formal settings

Based on the above codes, the ten studies' results were combined. Due to the lack of availability of some original databases, there were overlaps that could not be adjusted; consequently, the weighted results could not be shown. However, a comparison can be done with each research study's results. A total of five studies showed that most research was carried out in hybrid environments. There is a significant difference between older studies, where the most common environment was formal, and newer studies, in which the most used environment was an informal one. Table 14 shows the distribution of the studies by learning environment, and Table 15 shows the distribution per years.

Table 14. Distribution of studies by learning environment in mobile learning research from 2009 to 2018

STUDY	SAMPLE SIZE	FORMAL	INFORMAL	HYBRIDS/A
(Bhat & Al Saleh, 2015)	13	17%	16%	67%
(Chee et al., 2017)	144	8%	11%	81%
(Crompton & Burke, 2018)	72	54%	36%	8%
(Frohberg et al., 2009a)	102	27%	42%	32%
(Fu & Hwang, 2018)	90	30%	45%	25%

(Hwang & Wu, 2014)	214	39%	18%	43%
(Krull & Duart, 2017)	233	16%	24%	60%
(Y. T. Sung et al., 2016)	110	56%	19%	25%
(Wu et al., 2012)	164	66%	7%	27%
(Zheng et al., 2018)	34	21%	50%	29%
Mean	118	33%	27%	40%

Table 15. Distribution of studies by formal and informal environment in mobile learning research across the recent years

YEAR	STUDY	FORMAL	INFORMAL
2009	(Frohberg et al., 2009a)		1
2012	(Wu et al., 2012)	1	
2014	(Hwang & Wu, 2014)	1	
2015	(Bhat & Al Saleh, 2015)	1	
2016	(Y. T. Sung et al., 2016)	1	
2017	(Chee et al., 2017)		1
2018	(Crompton & Burke, 2018)	1	

Learning domain

Almost half of the studies (11) included in this research analysed the impact of the learning domain. All the phrases used to refer to this category included the word domain or discipline and included the following: subject domain, learning domain, subject matter domain, learning subjects, academic disciplines, subject area, disciplines, and courses. The learning contents varied significantly between the studies. More than 50 different codes were identified and grouped into the following seven categories: engineering (including computers), language and art, mathematics, science, social science, and others and no specified (Chee et al., 2017; Hwang & Tsai, 2011).

The results shown in Table16 demonstrate that science and social science are the two domains most studied in the mobile learning field. Mathematics is the academic discipline less frequently examined in mobile learning studies. However, the results are limited to the group sample of each study. Some studies' participants were limited to individuals with a higher education (Krull & Duart, 2017; Pimmer et al., 2016; Virtanen et al., 2018), and others were focused on K through 12 participants (Cheung & Hew, 2009).

Table 16. Distribution of learning domains groups for mobile learning research from 2010 to 2018

STUDY	ENGINEERING	LANGUAGE & ART	MATHEMATICS	SCIENCE	SOCIAL SCIENCE	OTHER
(Hwang & Tsai, 2011)	14%	16%	4%	19%	7%	40%
(Hwang & Wu, 2014)	9%	18%	3%	9%	22%	40%
(Krull & Duart, 2017)	0%	0%	0%	15%	54%	30%
(Y. T. Sung et al., 2016)	12%	35%	10%	29%	9%	5%
(Tingir et al., 2017)	0%	60%	20%	20%	0%	0%
(Wu et al., 2012)	0%	0%	0%	65%	35%	0%
(Zheng et al., 2018)	0%	0%	0%	76%	24%	0%
(Baran, 2014)	0%	12%	9%	14%	3%	65%
(Chee et al., 2017)	4%	13%	3%	12%	8%	60%
(Crompton & Burke, 2018)	7%	21%	0%	6%	34%	31%
(Fu & Hwang, 2018)	15%	16%	3%	25%	22%	19%
Mean	**6%**	**17%**	**5%**	**26%**	**20%**	**26%**

Devices

The domain category devices were investigated by 14 studies. Combining all studies, coding was assigned to as many as 15 different devices, namely, mobile phones, smartphones, tablets, laptops, PDAs, handheld PCs, iPads, handheld devices, pocket PCs, notebooks, iPods, MP3 players, eBook readers, wearables devices, and game consoles. Coding and evaluating devices are challenging and present several limitations. On the one hand, owing to the rapid advancement of mobile technologies, the types of mobile devices adopted by researchers and educators have significantly changed in the past decade (Hwang & Wu, 2014). Researchers found that the latest technology provides better portability, interactivity, and autonomy to meet the needs of mobile learning. Consequently, research findings are likely to change with ongoing technological development. On the other hand, diverse technology devices are applied simultaneously in education, as learners start to use their own mobile devices for learning. Mobile learning devices are losing ground to the emerging platforms where learners can retrieve the same learning resources with different types of devices. Multiple device usage and BYOD (Bring Your Own Device) strategies are widely integrated into educational environments. According to Horizon report 2017, in the US, each student has on average 3.2 devices (Johnson et al., 2017). BYOD goes beyond access to devices, as students are no longer limited to institutional systems but increasingly have their own internet access and make use of their own services. Devices are important, but the associated systems and networks are equally significant (Traxler, 2016).

Some recent studies proved that the non-significant differences in device type suggest that the device effect on student achievement does not exist (Tingir et al., 2017). Consequently, this study could not answer the research question related to which mobile devices are more used.

Methodologies

Research methods

This study found 5 articles where methods were grouped into three main categories, which were coded as quantitative, qualitative and mixed (Chee et al., 2017; Fu & Hwang, 2018; Kaliisa & Picard, 2017; Krull & Duart, 2017; Zheng et al., 2018). Five articles included in this investigation performed meta-analysis research that focused on the use of quantitative methodologies or experimental or quasi-experimental research (Alrasheedi & Capretz, 2015; Mahdi, 2018; H. Y. Sung et al., 2016; Tingir et al., 2017; Wu et al., 2012). In social science research, often, strategies and methodologies are difficult to differentiate. Guba (1981) introduced different strategies to deal with fundamental research criteria (credibility, transferability, dependability, and confirmability). This study highlighted the importance of defining the appropriate strategy, where different methodologies, namely, quantitative and qualitative, could be applied .(Rikala, 2015) adopted and extended Guba's strategies, including triangulation, peer debriefing, research context descriptions, interactive comparations, and reflective journals. Based on the above, for our study, the research methods were coded into three groups: quantitative; qualitative and mixed. Table 17 shows the research methodologies results.

Table 17. Research methodologies used in mobile learning research from 2009 to 2018

STUDY	SAMPLE SIZE	QUANTITATIVE	QUALITATIVE	MIXED	NOT SPECIFIC
(Chee et al., 2017)	144	48%	16%	19%	18%
(Fu & Hwang, 2018)	90	36%	12%	37%	16%
(Kaliisa & Picard, 2017)	31	19%	10%	42%	29%
(Krull & Duart, 2017)	233	43%	46%	11%	N/A
(Zheng et al., 2018)	34	56%	0%	44%	N/A

With the exception of (Krull & Duart, 2017), the quantitative approach is the most employed research methodology for mobile learning studies, followed by mixed methods. Fu and Hwang (2018) analysed this tendency, concluding that quantitative analysis and mixed analysis increased enormously in the last 10 years, as researchers emphasized the empirical experience in both experimental environments and real scenarios.

Data collection methods

A total of 7 studies analysed the different data collection methods applied in mobile learning research (Cheung & Hew, 2009; Crompton & Burke, 2018; Kaliisa & Picard, 2017; Krull & Duart, 2017; Virtanen et al., 2018; Wu et al., 2012; Zheng et al., 2018). As many as 21 different collection methods were identified: audio recording, classroom observation, content analysis, discussions, document review, feedback, field notes, focus groups, interviews, observations, observations via video, peer teaching, process data, product data, questionnaires, surveys, systematic reviews of the literature, teacher blogs, tests or quizzes, weekly journals and written materials. These collection methods were grouped into five categories adapted from Cheung and Hew (2009) and Krull and Duart (2017). The codes included the following: questionnaires and surveys, interviews and focus groups, content analysis, observation, and mixed methods. Table 18 depicts the data collection methods most used in mobile learning research.

Table 18. Research methodologies used in mobile learning research from 2009 to 2018

STUDY	SAMPLE SIZE	QUESTION NAIRE	INTERVIEW	CONTENT ANALYSIS	OBSERVA TION	MIXED METHODS
(Cheung & Hew, 2009)	44	54%	18%	21%	7%	0%
(Crompton & Burke, 2018)	72	54%	15%	3%	0%	28%
(Kaliisa & Picard, 2017)	31	54%	36%	6%	4%	0%
(Krull & Duart, 2017)	233	61%	18%	18%	3%	0%
(Virtanen et al., 2018)	7	36%	36%	27%	0%	0%
(Wu et al., 2012)	164	39%	4%	15%	5%	37%

The most used data collection method are questionnaires and surveys, observation is the category less used. Mixed methods category' results are limited by the studies not including this category. However, as per other results analysed in this study using mixed collection methods is a current trend: "The studies examined in this review used varied methodologies, with a majority being case studies or mixed method" (Baran, 2014, p. 7); "All of studies adopted mixed data sources to collect data" (Zheng et al., 2018, p. 12); "Of the articles reviewed, 79% represented investigations exploratory in nature using various data sources" (M. Liu et al., 2014, p. 6).

Outcome

Based on the studies analysed, there are different approaches to measure outcomes. Some studies referred to learning outcomes as the measure to determine if the use of mobile learning can improve or enhance the students' learning knowledge. In most cases, the authors labelled these outcomes as follows: positive, negative, and neutral. This research topic was investigated by 10 studies (Chee et al., 2017; Crompton & Burke, 2018; Fu & Hwang, 2018; M. Liu et al., 2014; Mahdi, 2018; Pimmer et al., 2016; Y. T. Sung et al., 2016; Virtanen et al., 2018; Wu et al., 2012; Zheng et al., 2018). Table19 shows the results of the five studies reporting quantified outcome results. The other five studies reported overall positive outcomes (Cheung & Hew, 2009; Pimmer et al., 2016; Y. T. Sung et al., 2016; Virtanen et al., 2018).

Table 19.Mobile learning research outcomes from 2009 to 2018

STUDY	SAMPLE SIZE	POSITIVE	NEGATIVE	NEUTRAL
(Chee et al., 2017)	144	53%	3%	44%
(Crompton & Burke, 2018)	72	70%	4%	26%
(Hwang & Wu, 2014)	214	32%	7%	61%
(M. Liu et al., 2014)l	63	75%	N/A	25%
(Wu et al., 2012)	164	86%	1%	13%

A second approach included focusing on the affective domain (Cheung & Hew, 2009; Pimmer et al., 2016). The results showed that overall, students are engaged and like using handheld devices. Finally, to analyse mobile learning outcomes, on top of learning knowledge and satisfaction, a third approach added a new dimension, namely, usage. Usage measures the frequency, intensity and/or quality of the learners' engagement. According to Pimmer et al. (2016), this last aspect is an important complementary indicator because mobile learning activities that are highly rated but rarely used by learners would have only limited effects. Three of the studies included in this investigation (Frohberg et al., 2009a; Pimmer et al., 2016; Y. T. Sung et al., 2016) highlighted the importance of underpinning mobile learning designs to pedagogical strategies, curriculum and to the further assessment of skills in order to ensure accurate outcomes' measurement.

3.2. Study 2: "Characteristics, functionalities and benefits of mobile learning: systematic review of the literature." [2]

3.2.1. Introduction

The main objective of this study is to analyse the evolution and trends of mobile learning, as well as to identify the characteristics and functionalities that enhance the main learning principles. The research is based on a systematic review of the literature of 41 studies. The results highlight the evolution since the beginning of the millennium, where mobile learning focused on eminently technological attributes, its subsequent evolution towards a pedagogical dimension and recently its expansion through the social dimension. The main contribution of this study is the identification of the main characteristics and functionalities of mobile learning as catalysts of fundamental principles of learning.

Este estudio tiene como principal objetivo analizar la evolución y tendencia del concepto de mobile learning, así como identificar las características que proporcionan las funcionalidades que potencian los principales paradigmas y modelos de aprendizaje. Estas características y funcionalidades sirven para ayudar a los profesionales en el diseño la adopción de mobile learning. Específicamente esta investigación pretende dar respuesta a las siguientes preguntas de investigación:

RQ1. ¿Cómo ha evolucionado el concepto de mobile learning?

RQ2. ¿Cuáles son las principales características y funcionalidades de mobile learning?

RQ3. ¿Qué beneficios pedagógicos potencia mobile learning?

3.2.2. Methodology

[2] Moya, S., & Camacho, M. Características, funcionalidades y beneficios de m-learning: revisión sistemática de la literatura. *Journal of New Approaches to Educational Research*. Under review

Para dar respuesta a las preguntas de investigación y con el objetivo de proporcionar una síntesis imparcial, resumir y generalizar las tendencias de conocimiento relevantes, el enfoque metodológico de este estudio es una revisión sistemática de la literatura (Hemingway & Brereton, 2009). Para garantizar que el proceso de revisión sea riguroso y válido, se siguió un protocolo de proceso detallado, este estudio se basa en la metodología propuesta por (Okoli & Schabram, 2010) orientada a estructurar y organizar la revisión sistemática de literatura mediante el proceso que se ilustra en la Figura 17.

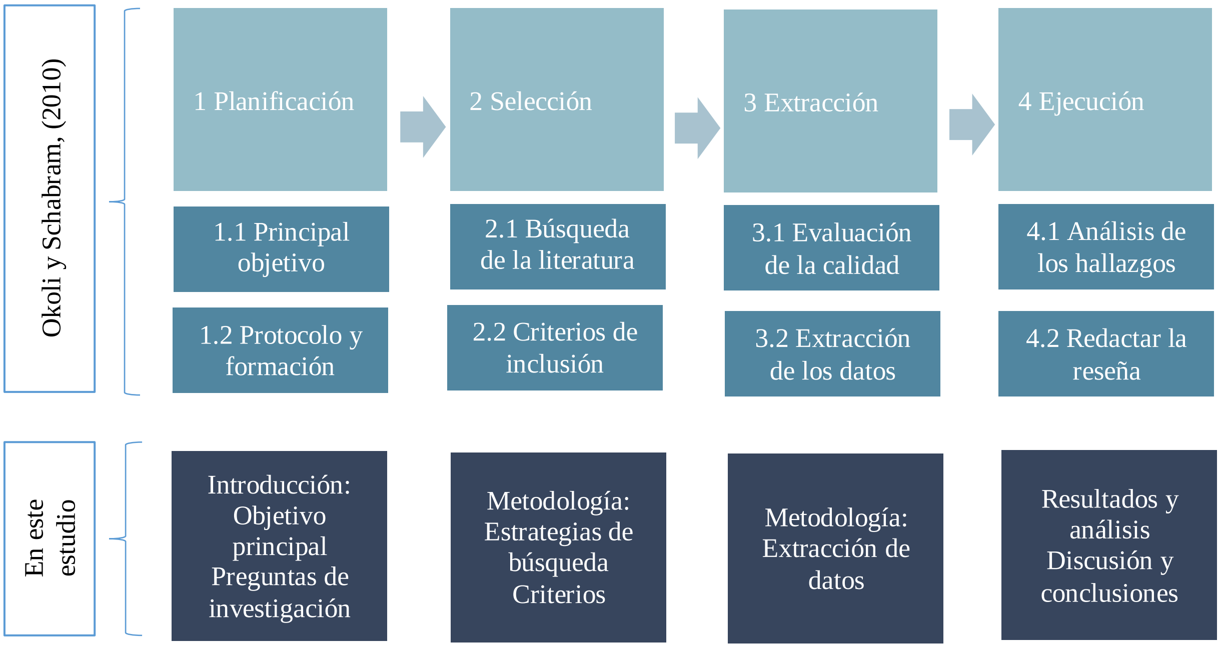


Figure 17. Proceso de revisión sistemática de literatura (Adapted from Okoli & Schabram, 2010, p. 9)

Estrategia de búsqueda

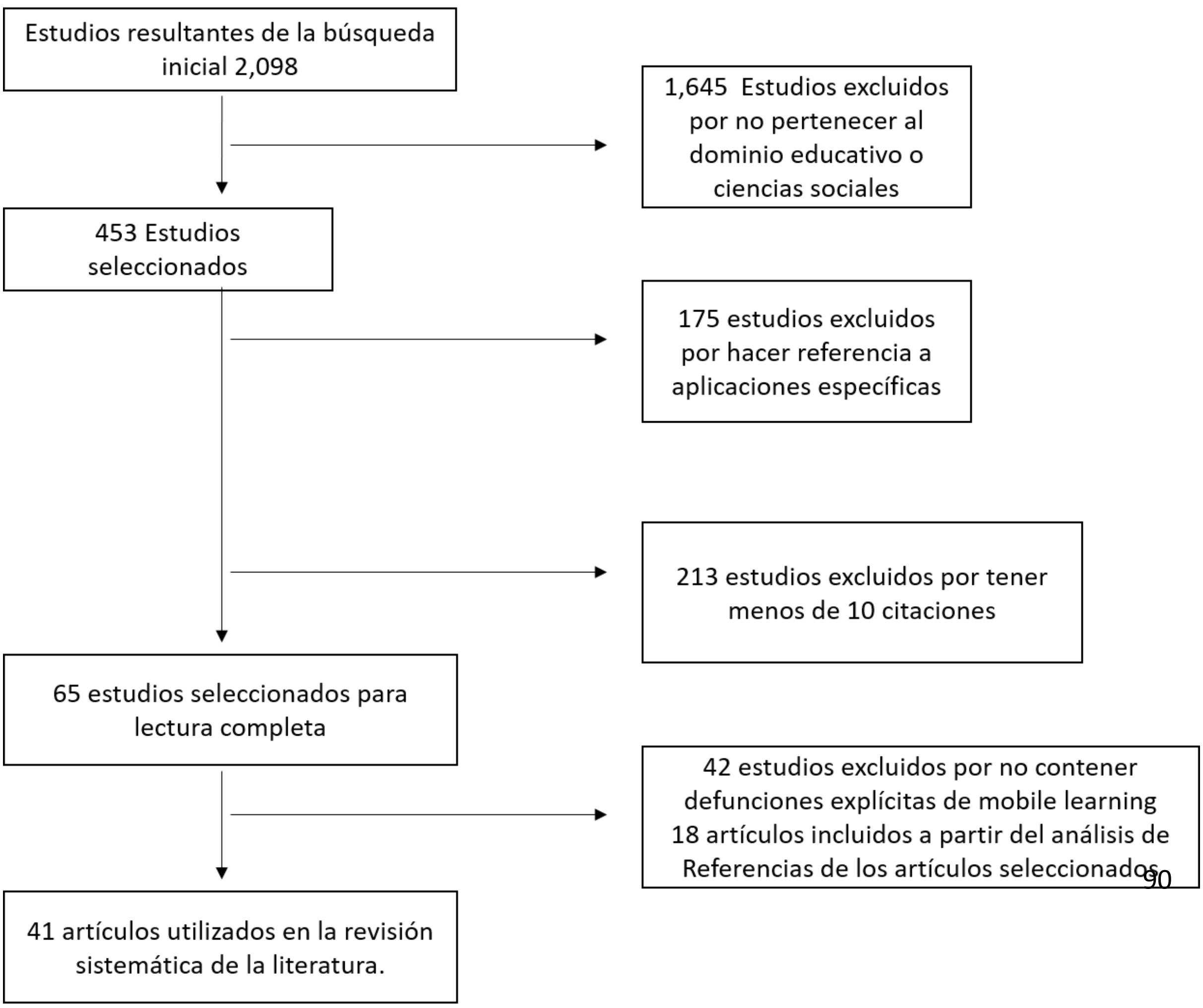
La búsqueda de bibliografía se ha basado en conceptos (Webster & Watson, 2002). Las expresiones «mobile learning» o «m-learning» o «ubiquitous learning» y «definition» o «characteristics» o «functionalities» han sido utilizadas en títulos y resumen durante la primavera de 2019. La búsqueda electrónica se completó en la fuente Web of Science que ha sido recomendada para realizar revisiones en el ámbito de educación (Fu & Hwang, 2018) con una búsqueda manual a partir de referencias de los artículos analizados

Criterios de inclusión

El proceso de filtro ha incluido diferentes variables y criterios:

(1) Que incluyan los términos de búsqueda descritos anteriormente.
(2) Que hayan sido publicados por una revista internacional o editorial en el ámbito de la educación o ciencias sociales.
(3) Excluir aplicaciones de mobile learning específicas como realidad aumentada.
(4) Incluir estudios con número de citas superior a 10.
(5) Incluir estudios que incluyan una definición de mobile learning o especifiquen sus características o sus funcionalidades.

La figura 18 muestra el proceso de selección de estudios mediante una representación gráfica adaptada de Yousra Banoor et al., (2019). Se identificaron 41 artículos que contenían definiciones de mobile learning como elegibles para la revisión. La extracción de datos ha sido realizada en base a las preguntas de investigación. Mediante la construcción de una matriz de metadatos con los siguientes parámetros: código, título, año, autores, citas, revista, definición de mobile learning, características de mobile learning, funcionalidades y aportación a paradigmas de educación. La figura 18 muestra este proceso. El Apéndice 1



contiene el enlace a la tabla de metadatos.

Figure 18. Proceso de selección de estudios (Adaptado de Yousra Banoor et al., 2019)

Criterios de inclusión

La extracción de datos se ha realizado identificando las definiciones de mobile learning de los estudios y posteriormente identificando las características y funcionalidades. Los datos se han estructurado en una tabla de metadatos. El Apéndice 1 contiene el enlace a la tabla de metadatos.

3.2.3. Results

Definiciones de mobile learning

Varios autores sitúan el concepto de mobile learning como una evolución en la tecnología educativa (Peng et al., 2009; Rikala, 2015). Existen numerosos estudios que definen el mobile learning, la mayoría de ellos lo hacen destacando alguna de sus características o funcionalidades, consecuentemente el concepto ha ido evolucionando paralelamente con las nuevas funcionalidades de mobile learning.

A partir de la búsqueda bibliográfica y el análisis sistemático, se han identificado diferentes categorías que clasifican las principales aportaciones de mobile learning. Sharples & Pea, (2014) identificaron tres fases en la evolución de mobile learning: i) enfoque en dispositivos móviles, ii) aprendizaje fuera del aula y iii) movilidad del estudiante e información. Trifonova (2003) clasificó la investigación sobre mobile learning en tres áreas principales: i) infraestructura, ii) contenido y comunicación iii) colaboración. Winters (2006) detalló cuatro perspectivas de las definiciones de mobile learning: i) relación tecno céntrica ii) relación con e-learning, ii) aumentando la educación formal y iv) centrado en el alumno. De manera similar, Koole (2009) identificó tres aspectos de mobile learning: i) dispositivo, ii) alumno y iii) aspectos sociales. Recientemente, Grant (2019) categorizó las definiciones de mobile learning en base a las siguientes categorías: i) relación con la educación a distancia, ii) explotación de dispositivos y tecnologías, iii) mediación con tecnología y iv) naturaleza nómada del alumno y aprendizaje. En base al análisis de estas categorías, este estudio utiliza tres perspectivas recurrentes de mobile learning que guían el posicionamiento de sus principales atributos: aspectos tecnológicos, pedagógicos y sociales.

(1) Los *aspectos tecnológicos*: las definiciones incluidas en esta categoría hacen referencia a mobile learning como un el aprendizaje mediante la utilización de un dispositivo móvil. Algunos autores hacen referencia a algunas de las características técnicas como la disponibilidad y accesibilidad de dispositivos, conectividad y servicios de datos como GPS. Sharples & Pea (2014) hace referencia al enfoque en dispositivos móviles; Trifonova (2003) se refiere a la infraestructura; Winters (2006) lo cita como tecno céntrico; Koole (2009) hace referencia al dispositivo y Grant (2019) se refiere a explotación de dispositivos y tecnologías.

(2) El *enfoque pedagógico* engloba las aportaciones de mobile learning en el proceso de aprendizaje referidos al contexto espaciotemporal, currículum, evaluación, así como procedimientos y estrategias asociados a los diferentes paradigmas pedagógicos. Esta dimensión se centra en los elementos del aprendizaje, donde la utilización de tecnología es un elemento más facilitador del aprendizaje. Sharples & Pea (2014)se refieren al aprendizaje fuera del aula; Trifonova (2003)nombra esta categoría como contenido y comunicación; Winters (2006) utiliza dos categorías dentro del enfoque pedagógico, potenciando el aprendizaje informal y centrado en el alumno; Koole (2009) nombra al alumno en esta categoría e incluye los aspectos pedagógicos del aprendizaje; Grant (2019) utiliza las categorías de mediación con tecnología.

(3) La *dimensión social* recoge las características que afectan a las relaciones entre la comunidad educativa durante el proceso de aprendizaje. (Sharples & Pea (2014) identifican este constructo como movilidad del estudiante e información; Trifonova (2003) identifica este enfoque como colaboración; Koole (2009) se refiere a aspectos sociales; Grant (2019) se refiere a la naturaleza nómada del aprendiz y el aprendizaje.

En base a esta categorización se han clasificado las 41 definiciones de mobile learning que se han extraído de la revisión sistemática de la literatura. La clasificación ha sido realizada por parte de las dos investigadoras. Mayoritariamente, las definiciones contienen elementos atribuibles a más de una categoría.

Las primeras definiciones corresponden a principios del milenio y tienden a posicionarse en los aspectos tecnológicos del concepto, posteriormente se observa una evolución hacia aspectos pedagógicos y en los últimos años incorpora la dimensión social. La Figura 19 muestra esta tendencia basado en los datos extraídos de los estudios analizados. Estos hallazgos son consistentes con estudios anteriores (Sharples et al., 2010; Traxler, 2010).

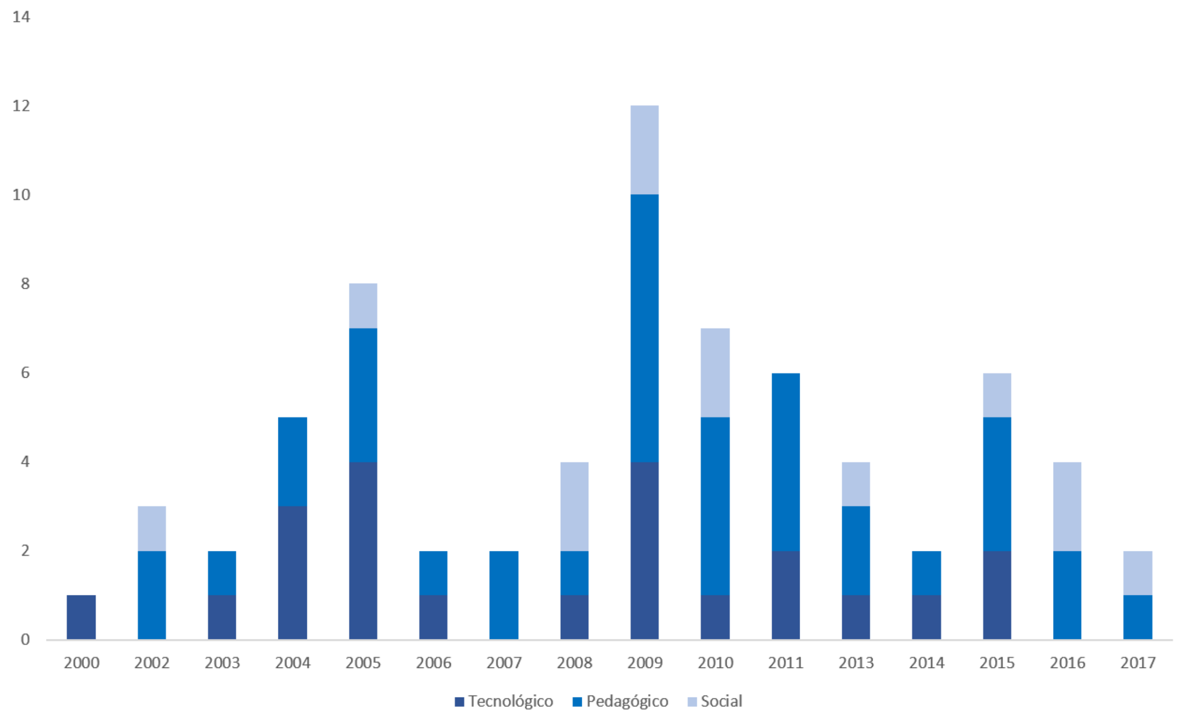


Figure 19. Evolución de los enfoques destacados en las definiciones de mobile learning

Características de mobile learning

Paralelamente a la evolución del concepto de mobile learning, las definiciones han ido destacado diferentes características y funcionalidades, inicialmente enfocadas en aspectos técnicos, evolucionando a características pedagógicas y finalmente incluyendo características de la dimensión social. Con el fin de acotar la lista de características de mobile learning, este estudio se centrará exclusivamente en las características derivadas explícitamente de las definiciones analizadas. De acuerdo con estas definiciones, las principales características de mobile learning son:

(1) *Accesibilidad*: el aprendizaje puede ocurrir en cualquier momento, derivado de la accesibilidad a los dispositivos móviles y su conectividad desde múltiples fuentes. En los estudios incluidos en la revisión sistemática, a menudo se hace referencia a esta

característica como «anytime» en las definiciones (Geddes, 2004; Kukulska-Hulme & Viberg, 2018; Martin & Ertzberger, 2013; Motiwalla, 2007; Ozdamli & Cavus, 2011; Sharples et al., 2010; Shih et al., 2011; Traxler, 2010).

(2) *Inmediatez:* esta característica permite el acceso a la información y la interactividad de manera inmediata (Karimi, 2016; Ozdamli & Cavus, 2011; Peng et al., 2009; Walker, 2006).

(3) *Ubicuidad*: referido a la capacidad que mobile learning pueda ocurrir en cualquier contexto y en cualquier situación, a menudo expresado en las definiciones como «anywhere» (Cochrane, 2010; Crompton, 2013; Geddes, 2004; Huang & Chiu, 2015; Hwang & Tsai, 2011; Kukulska-Hulme et al., 2011; T. Mifsud & Casey, 2009; Motiwalla, 2007; Peng et al., 2009; Rikala, 2015; Shih et al., 2011; Tétard et al., 2008; Traxler, 2010; Vavoula & Sharples, 2002; Virtanen et al., 2018).

(4) *Interactividad*: la comunidad educativa puede interactuar de múltiples maneras con su entorno, mobile learning proporciona entornos de aprendizaje interactivos (Crompton, 2013; Koole, 2009; Kukulska-Hulme et al., 2011; Ozdamli & Cavus, 2011; Sharples et al., 2010).

Funcionalidades de mobile learning

Las características excepcionales del mobile learning permiten unas funcionalidades que lo convierten en un excelente catalizador de innovadoras estrategias de aprendizaje. Como parte del proceso de revisión sistemática de la literatura se han identificado diferentes funcionalidades de mobile learning. La agrupación de las diferentes funcionalidades identificadas se ha basado en un enfoque centrado en el concepto (Webster & Watson, 2002). Las dos autoras examinaron y analizaron exhaustivamente los estudios incluidos en este estudio, esta clasificación se completó con otros estudios con referencias explícitas a funcionalidades de mobile learning. La tabla 20 detalla para cada una de las funcionalidades identificadas y la fraseología utilizada en los estudios analizados.

Table 20. Funcionalidades de mobile learning

FUNCIONALIDAD	ESTUDIO
Autonomía	Centrado en la construcción del conocimiento, no en la reproducción (Jonassen, 1994); Dejar tiempo para explorar (A. Herrington et al., 2009); Acceso múltiple a los recursos de aprendizaje(G. Chen et al., 2008); Centrado en el alumno (Khaddage et al., 2016); El alumno está involucrado y comprometido (Grant, 2019)
Flexibilidad	Proporcionan múltiples representaciones de la realidad (Jonassen, 1994); Aprendizaje adaptativo (Liaw et al., 2010); Cambio continuo entre múltiples tareas de aprendizaje (G. Chen et al., 2008); Nómada (Stanton & Ophoff, 2013); Los dispositivos son móviles (Grant, 2019)
Permanencia	Contenido y distribución de conocimiento (Liaw, 2010); En cualquier momento (Traxler, 2010); A través del tiempo (G. Chen et al., 2008); Uso del tiempo y el espacio (Kearney et al., 2012); Los servicios de datos son persistentes (Grant, 2019)
Instantaneidad	Conectividad (Churchill & Churchill, 2008); Utilizar ML espontáneamente (A. Herrington et al., 2009)(Herrington et al., 2009); Justo a tiempo (Traxler, 2010)
Contextualización	Contextualización (Jonassen, 1994); Portabilidad (Klopfer et al., 2002); Portabilidad (Churchill & Churchill, 2008); Utilizar ML en diferentes contextualizaciones (Herrington et al., 2009); En cualquier lugar (Traxler, 2010); A través de ubicaciones (G. Chen et al., 2008); Autenticidad (situacional y contextualización) (Kearney et al., 2012); Ubicuidad (Stanton & Ophoff, 2013); Ubicuo(Khaddage et al., 2016); Los contextos impactan el aprendizaje (Grant, 2019)
Situacionalidad	Entornos de aprendizaje basados en casos reales (Jonassen, 1994); Fusionando mundos digitales y físicos (Klopfer et al., 2002); Sensibilidad contextual (Churchill & Churchill, 2008); Experiencias del mundo real (Herrington et al., 2009); Abarcando mundos físicos y digitales (G. Chen et al., 2008); Autenticidad (situacional y contextualización) (Kearney et al., 2012); Sensibilidad contextual (Stanton & Ophoff, 2013); Situado (Khaddage et al., 2016); El contenido es móvil (Grant, 2019)
Informalidad	Donde sea (Herrington et al., 2009); Abarcando el aprendizaje formal e informal (G. Chen et al., 2008); Autenticidad (situacional y contextualización) (Kearney et al., 2012)
Personalización e inclusión	Personalización (Klopfer et al., 2002); Churchill & Churchill, 2008; Herrington et al., 2009; Liaw, 2010; Stanton & Ophoff, 2013; Kearney et al., 2012); Solo para ellos (Traxler, 2010); Abarcando el aprendizaje personalizado y social (G. Chen et al., 2008); Individualizado; Tutor es accesible (Grant, 2019)
Sociabilización	Interactividad social y conectividad (Klopfer et al., 2002); Interactividad social (Churchill & Churchill, 2008); ML puede enfocarse individualmente como en colaboración (Herrington et al., 2009); Interactivo; colaborativo (Liaw, 2010); Todos pueden producir aprendizaje (Traxler, 2010); Abarcando el aprendizaje personalizado y social (G. Chen et al., 2008); (Kearney et al., 2012); Interactividad social (Stanton & Ophoff, 2013); (Khaddage et al., 2016); Los estudiantes son móviles (Grant, 2019)
Colaboración y cooperación	Apoyar la construcción colaborativa del conocimiento (Jonassen, 1994); ML puede enfocarse individualmente como en colaboración (Herrington et al., 2009); Interactivo; colaborativo (Liaw, 2010); Todos pueden producir aprendizaje (Traxler, 2010)
Retroalimentación	Facilitates monitoring process (Baran, 2014); Los profesores en formación, los mentores y los formadores de profesores pueden conectarse fácilmente a través de herramientas móviles para compartir comentarios (Baran, 2014); ML proporciona nuevas oportunidades de retroalimentación (Ada, 2018)

(1) *Autonomía*: mobile learning facilita la autonomía del alumno y potencia su responsabilidad como elemento central en el aprendizaje. Derivado fundamentalmente de la característica de mobile learning de proporcionar acceso permanente e inmediato facilita un marco de experiencias donde los participantes se asumen un rol activo en el proceso de aprendizaje, en lugar de receptores pasivos de conocimiento (Looi et al., 2010). Paralelamente se maximiza el tiempo en clase en actividades participativas y colaborativas donde los educadores asumen un rol de facilitador, proporcionando orientación personalizada (Baran, 2014; Bishop & Verleger, 2013). Mobile learning promueve mejorar los niveles y calidad de la participación de los estudiantes en el aprendizaje derivado de la motivación y la satisfacción (Pimmer, 2016; Rikala, 2015).

(2) *Flexibilidad* en el aprendizaje y adaptabilidad: mobile puede ser espontáneo, no anticipado y oportunista, estar en el lugar correcto en el momento adecuado para capturar eventos significativos y construir conocimiento. La flexibilidad que proporciona mobile learning permite la simultaneidad de recursos, simulaciones virtuales, velocidades, enfoques y tareas de aprendizaje (Grant, 2019; Liaw et al., 2010). Las características de accesibilidad e inmediatez proporcionan la flexibilidad en aprendizaje. Los alumnos pueden acceder a los materiales de aprendizaje de la manera que más les convenga y controlar el ritmo de aprendizaje (Liaw et al., 2010).

(3) *Permanencia* en el tiempo: mobile learning proporciona permanentemente recursos y estrategias de aprendizaje que ayudan a la construcción de conocimiento que es reutilizable, sostenible y escalable (Galanis et al., 2016; A. Herrington et al., 2009). La funcionalidad de permanencia de mobile learning está asociada con el concepto de lifelong learning o aprendizaje permanente, centrado en promover y facilitar aprendizaje continuo a lo largo de toda la vida. Peng et al. (2009) definió lifelong learning como una «mentalidad de aprendizaje en un proceso humano natural y adaptativo en el curso de la vida» (p. 11).

(4) *Instantaneidad* del conocimiento: de manera cada vez más frecuente, los servicios de datos y las redes están continuamente disponibles (Vázquez-Martínez & Cabero-Almenara, 2015). Esta funcionalidad, permite a los alumnos la espontaneidad, entendida como la oportunidad de aprovechar los momentos y espacios para aprender

de manera espontánea, según sus intereses y necesidades (A. Herrington et al., 2009). Traxler (2010) utiliza el término «just intime».

(5) *Contextualización* del aprendizaje: la ubicuidad de los dispositivos móviles permite la ubicuidad de los alumnos y permite el aprendizaje independientemente de la ubicación (A. Herrington et al., 2009). Mobile learning permite la contextualización constante, lo que proporciona experiencias múltiples de aprendizaje y potencia habilidades del siglo XXI como el pensamiento crítico La contextualización, igual que la Situacionalidad proporcionan autenticidad al aprendizaje, las experiencias auténticas acercan al estudiante al mundo real y dan significado al aprendizaje (Crompton, 2013; Mifsud, 2014). Mobile learning contextualiza el aprendizaje, que puede ocurrir dentro y fuera del aula, en laboratorios o en cualquier ubicación (Churchill et al., 2016). El acceso a tecnologías de detección como GPS (Global Position System), RFID (identificación por radiofrecuencia) o códigos QR (respuesta rápida) han permitido que el aprendizaje pueda ser contextualizado en el mundo real (Hwang, 2014). Mobile learning implica el uso de dispositivos digitales móviles dentro y entre entornos o contextos de aprendizaje diseñados pedagógicamente (Cochrane, 2010). Las simulaciones virtuales, como la realidad virtual, o realidad aumentada, permiten contextualizaciones y entornos de aprendizaje muy cercanos a la realidad (Cochrane et al., 2017).

(6) *Situacionalidad*: mobile learning permite aprendizaje auténtico con experiencias reales que pueden ser físicas per también virtuales. Aprendizaje situacional es aquel que se produce en el lugar, a la hora y en las condiciones que se consideran más adecuadas para el alumno (Kukulska-Hulme et al., 2011). Mientras la contextualización proporciona escenarios de simulación para los alumnos que reproducen experiencias reales, la situacionalidad permite a los alumnos participar directamente de la experiencia real, en ambos casos proporcionando aprendizaje auténtico. El contexto del aprendizaje continuo es transversal y transcontextual, una experiencia de aprendizaje continuo puede ocurrir en diferentes entornos físicos o simulados, como el hogar y la escuela, o lugar de trabajo-universidad (Boticki et al., 2015).

(7) *Informalidad*: mobile learning facilita el aprendizaje informal y permite harmonizar la coexistencia de aprendizaje formal e informal (Impedovo, 2011; A. C. Jones et al., 2013; Koole, 2009). Definir el aprendizaje informal ha supuesto un reto para muchos investigadores, a menudo ha sido definido por contraste con aprendizaje formal. Galanis et al. (2016), definieron el aprendizaje formal como la educación recibida en un centro educativo reconocido que conduce a una certificación. Los niveles de motivación del aprendizaje informal son sistemáticamente superiores a los del aprendizaje formal (Pimmer et al., 2016; Voogt et al., 2013).

(8) *Personalización*: la conectividad e interactividad de los dispositivos móviles proporcionan a mobile learning la capacidad de simplificar y promover la customización del contenido y estrategias pedagógicas, facilitando la autonomía y autorregulación del aprendizaje (Kearney et al., 2012; Motiwalla, 2007; Ozdamli & Cavus, 2011; Sharples et al., 2010).

(9) *Sociabilización*: Mobile learning estimula la interacción social y facilita la comunicación (Crompton, 2013; Crompton & Burke, 2018; Hwang & Tsai, 2011; Karimi, 2016; Koole, 2009; Ozdamli & Cavus, 2011; Rikala, 2015; Tétard et al., 2008). Las redes sociales son algunos de los catalizadores de esta funcionalidad en mobile learning (Fu & Hwang, 2018). Numerosos estudios avalan la contribución de las redes sociales en el aprendizaje, *Facebook*, *Twitter*, *Skype*, y *WhatsApp* destacan como los más utilizados. Las redes sociales se utilizan para facilitar que los estudiantes puedan compartir sus opiniones, difundir contenido y enlaces a recursos adicionales, y fomenta la interacción entre miembros del grupo (Al-Samarraie & Saeed, 2018; Boticki et al., 2015; Kukulska-Hulme et al., 2011; Motiwalla, 2007), de manera satisfactoria, reportando altos niveles de motivación, participación y resultados académicos (Vázquez-Martínez & Cabero-Almenara, 2015).

(10) *Cooperación y colaboración*: mobile learning favorece la cooperación entre diferentes actores de la comunidad educativa. Algunos autores se refieren a esta funcionalidad como «between areas of life» entre diferentes áreas de la vida (Vavoula & Sharples, 2002; Winters, 2006). El aprendizaje colaborativo como método de enseñanza mediante el cual los alumnos aprenden en grupo, compartiendo ideas, experiencias ayudándose los unos a los otros para lograr un objetivo de aprendizaje,

ha reportado resultados positivos académicos y afectivos tanto grupales como individuales (Fu & Hwang, 2018; Wu et al., 2012). Numerosos estudios han examinado el impacto positivo de la interactividad en el aprendizaje colaborativo (Chan et al., 2019).

(11) *Retroalimentación*: la conectividad y la interactividad permite evaluar el progreso de aprendizaje y proporcionar retroalimentación (Chan et al., 2019). Mobile learning facilita la retroalimentación auténtica, inmediata con soporte de criterios multidimensionales y utilizando instrumentos múltiples (Ada, 2018). Lai and Hwang (2015) es su estudio destacaron entre diez estrategias relevantes de moble learning, la coevaluación como estrategia para involucrar a los estudiantes para calificar y comentar los informes o proyectos de sus compañeros a través de dispositivos móviles basados en las rúbricas del docente.

Beneficios pedagógicos de mobile learning

Para mostrar los beneficios pedagógicos de mobile learning, este estudio se basa en el aporte a los 7 principios transversales que guían el desarrollo de entornos de aprendizaje en el siglo XXI publicados por la OCDE y basados en perspectivas tanto cognitivas como emocionales y biológicas (Dumont et al., 2010).

(1) *El alumno es el centro del aprendizaje.* El alumno se reconoce como el elemento central en los entornos de aprendizaje, se fomenta su responsabilidad y compromiso activo. Los alumnos construyen su propio aprendizaje a través del compromiso, la exploración activa y autorregulación del aprendizaje para alcanzar sus objetivos (Liaw et al., 2010). Mobile learning a través de la accesibilidad e inmediatez, proporciona la autonomía del alumno y permite la autorregulación de su aprendizaje (Grant, 2019; A. Herrington et al., 2009; Khaddage et al., 2016).

(2) *El aprendizaje es de naturaleza social*. La neurociencia confirma que aprendemos a través de la interacción social (Dumont et al., 2010). La interacción social se sitúa como uno de los pilares del constructivismo (Piaget, 1970; Vygosky, 1978). Mobile learning proporciona entornos de aprendizaje interactivos que promueven el aprendizaje a través de la interacción social (Crompton, 2013; Koole, 2009; Kukulska-Hulme et al., 2011; Ozdamli & Cavus, 2011; Sharples et al., 2010).

(3) *Las emociones son parte integral del aprendizaje*. El aprendizaje resulta de la interacción dinámica de las emociones, la motivación y la cognición, y estos están estrechamente entrelazados. Tener en cuenta las motivaciones permite que el aprendizaje sea más efectivo y agradable (Dumont et al., 2010). Pimmer et al. (2016) en su estudio concluyó que mobile learning proporcionaba altos niveles de motivación y satisfacción. La característica de mobile learning de ubicuidad, proporciona la informalidad, la situacionalidad y la motivación en el aprendizaje (Impedovo, 2011; A. C. Jones et al., 2013; Koole, 2009).

(4) *El aprendizaje debe tener en cuenta las diferencias individuales*. El entorno del alumno tiene que ser sensible a las diferencias individuales entre los alumnos. Los entornos de aprendizaje necesitan la adaptabilidad para reflejar estas diferencias (Dumont et al. 2010). La capacidad de personalización de mobile learning permite la customización de contenidos, la adaptación de estrategias pedagógicas (Ozdamli & Cavus, 2011; Sharples et al., 2010), así como la individualización en procesos emocionales y motivacionales y la inclusión social y cultural (Traxler, 2010).

(5) *El esfuerzo de todo el alumnado es clave para el aprendizaje*. Los entornos de aprendizaje suponen un esfuerzo y desafío para los estudiantes, optimizado para conseguir que el alumno alcance y supere sus niveles de capacidades (Dumont et al., 2010). La capacidad de acceso y disponibilidad permanente de recursos y estrategias pedagógicas de mobile learning, permite la construcción de conocimiento adaptable y sostenible (A. Herrington et al., 2009), dinamizando los niveles de esfuerzo de los alumnos. La personalización que facilita mobile learning ayuda a calibrar los niveles de esfuerzo y desafío durante el proceso de aprendizaje.

(6) *Evaluar para aprender*. Los entornos de aprendizaje deben contener estrategias de evaluación consistentes con las expectativas**.** Se debe transmitir de manera clara a los alumnos lo que se espera de ellos y cómo se les va a evaluar. De lo contrario, disminuye la motivación y los niveles de autorregulación del aprendizaje. La evaluación debe ser sustancial, regular y proporcionar una retroalimentación significativa a los alumnos, así como ajustar constantemente los procesos de aprendizaje (Dumont et al., 2010). Mobile learning facilita la retroalimentación auténtica, inmediata con soporte de criterios multidimensionales y utilizando

Designing a framework for mobile learning adoption and sustainable development

instrumentos múltiples que permite evaluar continuamente el progreso de los alumnos y los métodos de aprendizaje (Lai & Hwang, 2015).

(7) *Aprender es construir conexiones horizontales*. El entorno de aprendizaje promueve la conexión horizontal entre áreas de conocimiento, así como diferentes comunidades y el mundo en general. Las conexiones horizontales se dan también entre el aprendizaje formal y el aprendizaje auténtico (Dumont et al., 2010). El aprendizaje construye estructuras de conocimiento transferibles, se construye a partir de unidades discretas de aprendizaje que se integran matricialmente en marcos más amplios, para que ese aprendizaje se pueda transferir a nuevas situaciones. Las funcionalidades de contextualización y Situacionalidad, juntamente con colaboración y conectividad, promueven la construcción de conexiones horizontales.

CHAPTER 4

DESIGN CYCLE TWO: DEVELOPING AN INITIAL MOBILE LEARNING FRAMEWORK BASED ON DESIGN PRINCIPLES

This chapter develops the second phase of the design-based research methodology. Reeves (2006) referred to this phase as development of solutions informed by existing design principles and technological innovations. In this thesis this phase consists of two aims: first, identified and analysed theoretical background and identify of draft principles to guide the intervention design. Second, the development of the initial prototype based on draft principles. The third research question is associated with this chapter: RQ3. What are the main design principles used for the development of frameworks for the adoption and sustainable use of mobile learning?

Before presenting the studies, a detailed description of the theoretical background is included as a fundamental part to support this phase of the research. The theoretical background consists of analysing mobile learning frameworks to identify fundamental design principles and develop the basis for an initial prototype, a good basis for the construction of the initial mobile learning framework. The development of the initial mobile learning framework prototype is also based on the characteristics and features identified in the previous chapter.

Two articles support this second phase of the DBR process described by Herrington et al. 2007: “Design principles of mobile learning frameworks” where the main design principles are identified based on the main mobile learning frameworks; the second article: “Planning to implement change. Strategic Pillars to Lead Mobile Learning in the Secondary School Environment” develops the first prototype of mobile learning framework based on the design principles identified in the previous study.

4.1. Mobile learning frameworks

As highlighted in the introduction, the academic production of theoretical frameworks for the adoption of mobile learning is scarce (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). "Educational community needs a solid theoretical foundation for mobile learning and more guidance about how to use technologies and integrate them into their teaching more effectively" (Alsaadat, 2017,p.15). "There are few studies that mobile devices" (Ng & Nicholas, 2013, p.2).
This section includes analysis of mobile learning frameworks and models. Frameworks describe the conceptual interactions among components and ideas based on related concepts, while models represent descriptive representation of associations among elements in a framework according to the investigation of empirical data (Hsu & Ching, 2015).

As will be described in the second iteration of this study, a thorough systematic analysis of the literature has identified 20 academic publications that present a theoretical framework for the adoption of mobile learning published between 2006 and 2018 (Table 21).

Table 21 lists the 20 models and frameworks, showing the name of the study and the name of the Framework or model. Although not specifically mobile learning frameworks, two general technology integration were added to the selection due to its popularity (Crompton, 2017): TPACK framework (Mishra & Koehler, 2006) and SMAR framework (Puentedura, 2009).

Table 21. Theoretical Frameworks for Mobile Learning Adoption

STUDY	FRAMEWORK
(Mishra & Koehler, 2006)	Technological Pedagogical Content Knowledge (TPACK)
(Motiwalla, 2007)	A m-learning framework
(H. Liu et al., 2008)	Design framework for mobile learning(Peng et al., 2009)
(Peng et al., 2009)	The conceptual framework of ubiquitous knowledge construction
(Koole, 2009)	The framework for the rational analysis of mobile education (FRAME)
(Sharples & Vavoula, 2009)	M3 evaluation framework

(Puentedura, 2009)	Situation, augmentation, modification, redefinition
(Nordin et al., 2010)	A framework for mobile learning design requirements for lifelong learning
(Park, 2011)	Four types of mobile learning: a pedagogical framework
(Brummelhuis & van Amerongen, 2011)	The four in balance monitor
(Kearney et al., 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 et al., 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 et al., 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)	Mlearning integration framework
(Ada, 2018)	Mobile Learning Framework for Assessment Feedback

Technological Pedagogical Content Knowledge *(Mishra & Koehler, 2006)*

One of the most relevant mobile learning frameworks is the one related to the acquisition of the necessary skills in teachers: technological, pedagogical and knowledge competencies: Technological Pedagogical Content Knowledge (TPACK) (Koehler & Mishra, 2009; Mishra & Koehler, 2006). The inclusion of technological competence is an evolution of the model of Shulman (1986) that argued that teachers' competencies are based on two domains: pedagogical and knowledge. He further proposed the PCK model that consists of pedagogical knowledge (PK), content knowledge (CK) and PCK.

The concept of TPACK was elaborated from PCK (Mishra & Koehler, 2006), which stands for technological knowledge (TK) that is contextually situated within content, pedagogical knowledge and the interrelated knowledge between the two. The TPACK model is shown in Table 20.

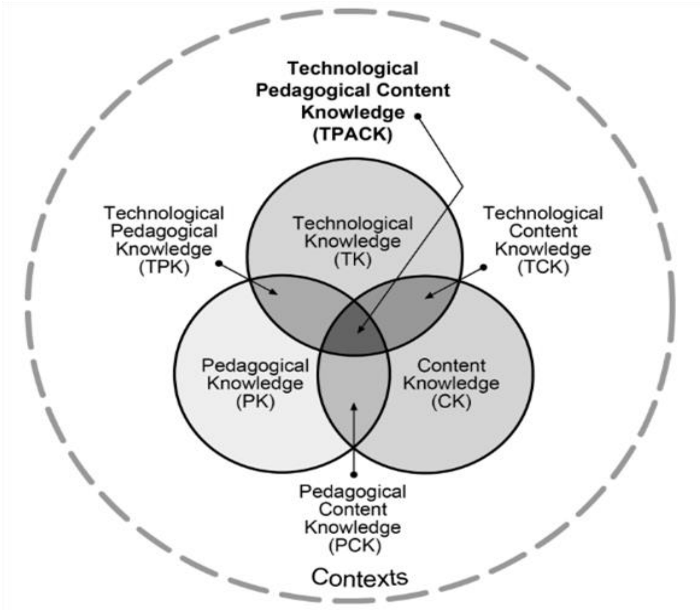


Figure 20. TPACK framework. Reproduced by permission of the publisher, © 2012 by http://tpack.org

Numerous studies have validated the framework reporting positive results, highlighting the interrelation of the different constructs of the framework (Archambault & Barnett, 2010; Chai, Koh & Tsai, 2010; Jang & Tsai, 2010; Koh, Chai & Tsai, 2010; Lee & Tsai 2010). The three main dimensions of the framework are content, pedagogical, and technological knowledge.

A mobile learning framework (Motiwalla, 2007)

The aim of the framework is to provide requirements to develop mobile learning applications. One of the axes of the model is based on a framework developed by Zhang (2003) oriented to the customization and adaptation of content delivery, based on the combination of two strategies push and pull. The author tested the framework in three courses for two semesters demonstrating users. that most learning pedagogies from constructive learning and conversation theories can be adapted for a mobile learning environment. Figure 21 reproduces the framework.

	Personalized Content	**Collaborative Content**	
PUSH Mechanism	*Pedagogical Agents & Mentors*	*Communication Aids*	*SMS, IM, Alerts, Scheduling Calendars*
PULL Mechanism	*System Tools & Resources*	*Simulated Classrooms*	*WML websites, Discussion Boards & Chat Forums*
	Alerts, Scheduling Calendars, WML websites	*SMS, IM, Discussion Boards & Chat Forums*	**M-learning Applications**

Figure 21. A m-learning framework (Motiwalla, 2007)

The dimensions used in Motiwalla's framework are personalization and social collaboration the dimension. The dimension in which to place the push and pull strategies would be related to the balance between the roles of the student and teacher, as the centre of the learning process the first and the second facilitator.

Design framework for mobile learning (H. Liu et al., 2008)

Liu et al. (2008) conducted a research based on the results of a projected launched in China targeted especially for learning English, named Mobileedu project. The project aimed to enrich people's learning experiences with mobile phones. They proposed a conceptual design framework for mobile learning, which they called design framework for mobile leering. Mobile learning design activity is the core aspect of the framework supported by constraint analysis, scenario design, technology environment design and support services. According to the authors, the framework was based on different fields, instructional design, user experience and wireless technology. MLearning activity design is the core aspect of the mlearning experience design framework, which not only bases on requirement and constraint analysis and refines on the results of the scenario design, but also interweaves with the functional aspects of technology environment design and non-functional aspects of the mobile learner support services (H. Liu et al., 2008, p. 185). Figure 22. Design framework for mobile learning (H. Liu et al., 2008, p. 185)2 reproduces the framework.

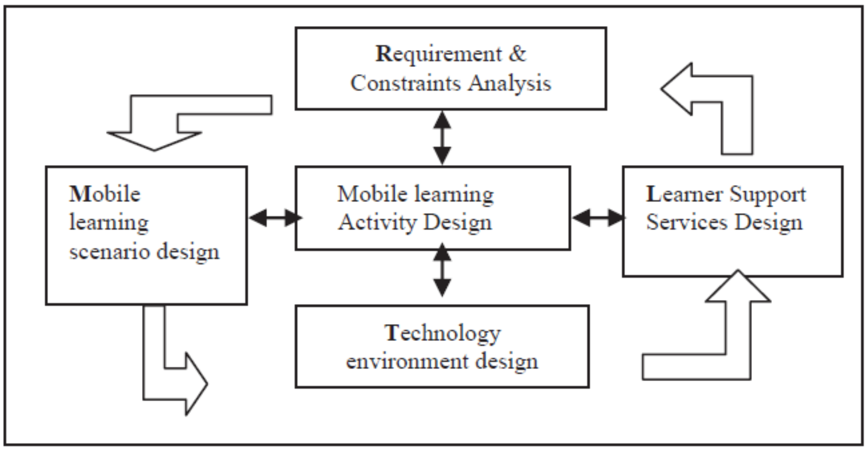


Figure 22. Design framework for mobile learning (H. Liu et al., 2008, p. 185)

The authors refer *to requirement and constrains analysis* as the user demands and the factors which influence their mobile learning experience and classified in two groups: general level which includes common features of mobile learning, development trend of ICT in education and motivations and expectations, a second group is concreated requirements referred to specific environment, socio-cultural features, learning characteristics. *Mobile learning scenario* design is referred to describe how learners with certain characteristics in certain settings carry out various activities to achieve their learning goals. *Technology* environment design is defined by authors as the mobile learning technological environment conditions such as databases, learning tools, platforms, networks etc. that supports and sustain the activities. The concept of *learner support* "comes from distance education, which usually means a range of services enabling learners to overcome difficulties, develop competencies and confidence in self-regulated" (H. Liu et al., 2008, p. 187). The four dimensions of Liu et al. (2008) framework is: Users requirements, scenario, technology, and learner support.

The conceptual framework of ubiquitous knowledge construction (Peng et al., 2009)

Peng et al. (2009) developed a framework named: "The conceptual framework of ubiquitous knowledge construction". This framework has 3 the components organized hierarchically. At the bottom, the mobile learning infrastructure (learners and tools) moving to pedagogical methods (constructivism and lifelong learning theories) and ending with the vision on the top (Ubiquitous knowledge construction). Figure 23 illustrates the framework.

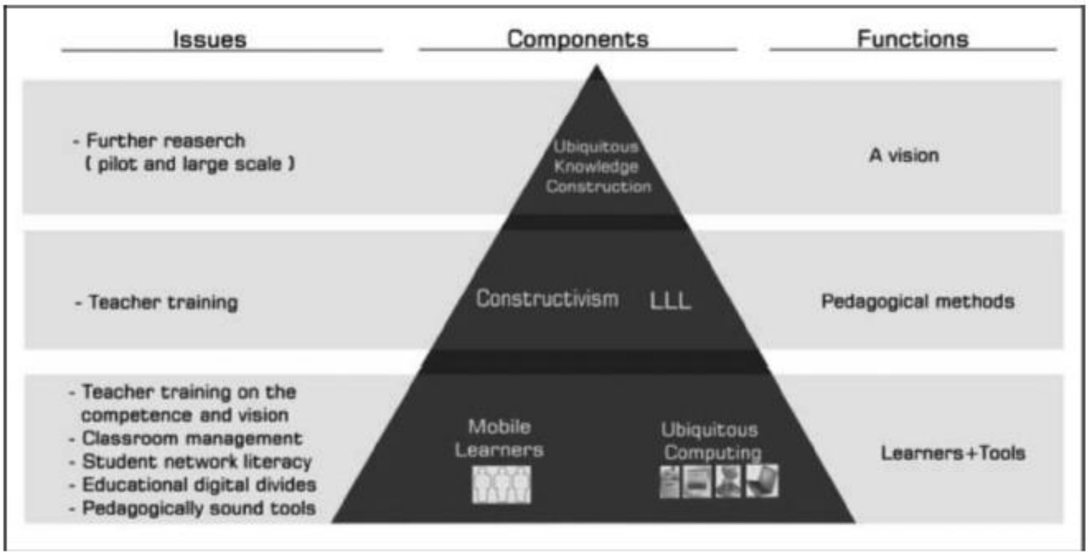


Figure 23. The conceptual framework of ubiquitous knowledge construction (Peng et al., 2009, p. 175)

At the bottom of the framework the authors proposed the term *mobile learner* derived from the term mobile people referred to "people that need alternative forms of competence development in which they can participate in collaborative activities at the time and place of convenience" (Peng et al., 2009, p. 176). In relation to tools function, the study defines ubiquitous computing as "wireless networks and mobile devices" and highlighted three aspects: software, hardware, and mobile interface.

Associated with mobile learners and ubiquitous computing the framework shows the following issues associated: educational digital divides, classroom management issues, network literacy, and the need to building a partnership for pedagogical sound educational tools. In the middle of the framework represents the pedagogical function, constructivism is the pedagogical model for mobile learning. The second pedagogical pillar is lifelong learning (LLL), defined in the study as a "mindset of learning in a natural, adaptive human process in the course of life". Knapper and Cropley (2000) referred to lifelong learning as the basic idea of deliberate learning that can and should occur throughout each person's life. Nordin et al. (2010, p. 130) showed an evolved interpretation as "the training of a workforce capable of adapting to a rapidly changing world". The issue identified at this stage is teacher training. At the top of the framework the study positions ubiquitous knowledge construction as the vision for future learning. The three different functions sustained by this framework are tools, mobile learner and pedagogical.

The framework for the rational analysis of mobile education *(Koole, 2009)*

The theoretical framework developed by Koole, 2009 Framework for the Rational Analysis of Mobile Education (FRAME) is based on three elements: device, learning and social aspects. She studied the interrelation between the three aspects and developed a framework positioning mobile learning at the intersection. The author identified each of the three elements: device aspect as "the physical, technical and functional characteristics of mobile device"; learner aspect " takes into account an individual's cognitive abilities, memory, prior knowledge, emotions and possible motivations"; and social aspect "takes into account the process of social interaction and cooperation" (Figure 24). Her framework was based on activity theory This analysis was represented by a Venn diagram that she called the Framework for the Rational Analysis of Mobile Education (FRAME).

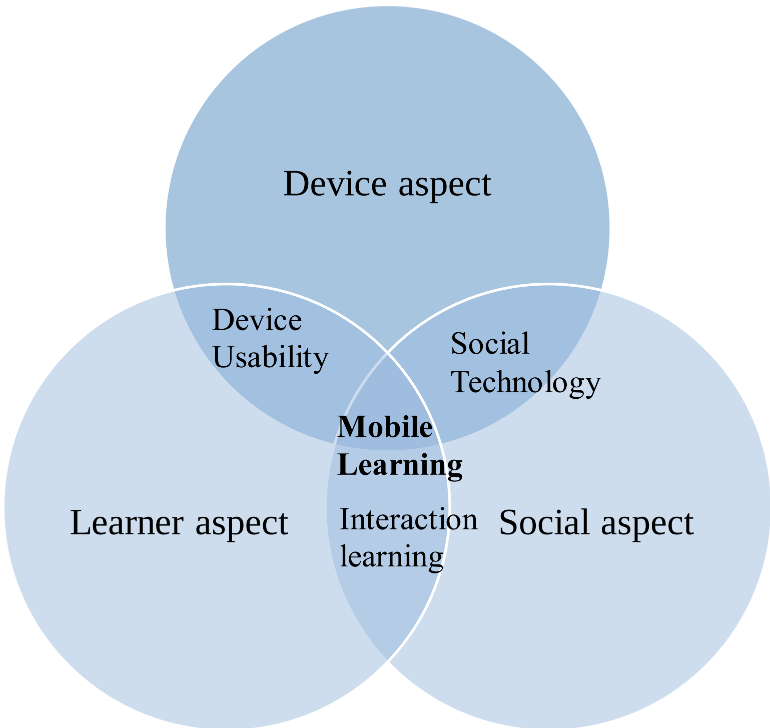


Figure 24. FRAM model (Koole, 2009, p. 27)

The three circles and the interactions contain attributes that belong to both aspects. The attributes of the device usability and social technology intersections describe the affordances of mobile technology. Whereas the attributes of the intersection labelled interaction learning contain instructional and learning theories with an emphasis on social constructivism (koole, 2009).

Koole attributed a series of characteristics of mobile learning to each of these intersections. In the device usability intersection highlighted the following characteristics (portability, information availability, psychological comfort, satisfaction). In relation to social technology interstation: device networking, system connectivity and collaboration tools. For the third intersection, interaction learning she stressed: interaction, situated cognition and learning communities. The three principal elements of Koole's framework are device, learner and social.

M3 evaluation framework *(Sharples & Vavoula, 2009)*

Sharples and Vavoula (2009) developed a framework oriented to evaluate mobile learning processes and outcomes. The model was based on the Lifecycle approach to educational technology evaluation proposed by (Meek, 2006), an approach consisting in a sequential of evaluation in different stages. The framework was developed in the specific environment of Myartspace, a tool that supports structured inquiry learning through technology that connects learning in the classroom with learning in museums and galleries. (Sharples & Vavoula, 2009, p. 5). The framework has three stages, micro, meso and macro evaluation and four phases (1) Requirements and analysis; (2) design of the user experience, (3) implementation, and (4) deployment of the service. Evaluation activities are introduced graduate changing the emphasis of the evaluation through the different phases as shown in Figure 25. The framework was oriented to mobile learning design and evaluation, the main dimensions are pedagogical, technological, and social, specifically experience-cantered activates.

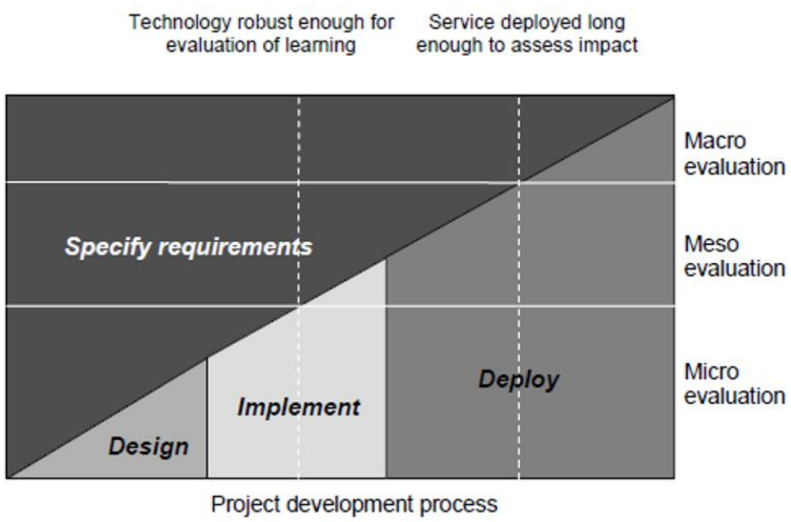


Figure 25. M3 evaluation framework (Sharples & Vavoula, 2009, p. 9)

Situation, augmentation, modification and redefinition *(Puentedura, 2009)*

Puentedura (2009) developed the SAMR model, used to categorize the different ways to integrate technology into teaching and learning. The first category is substitution were substitution characterized by no functional change; the second category is augmentation, where technology has functional improvement, Puentedura grouped those two categories and called enhancement learning. The third category modification where teach allows a significant task redesign and the fourth redefinition that allows the creation of new tasks, third and fourth categories were grouped and titled transformation learning. It is based on the qualitative degree of technology integration and the capacity of transforming non-digital learning. See Figure 26. SAMR model (Puentedura, 2009).

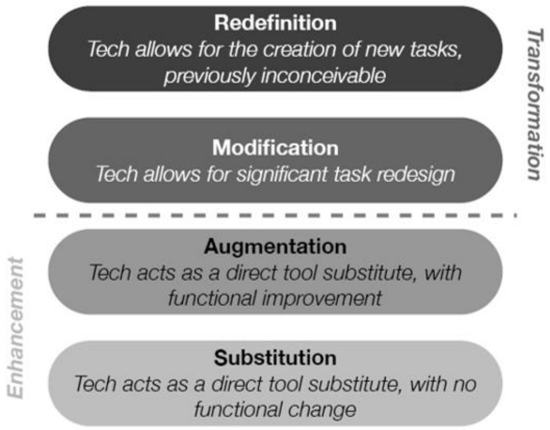


Figure 26. SAMR model (Puentedura, 2009)

A framework for mobile learning design requirements for lifelong learning (Nordin et al., 2010)

Nordin et al. (2010) proposed a framework named: "A framework for mobile learning design requirements for lifelong learning". Definitions provided in the study are shown above. Their study is based on the framework of H. Liu et al. (2008) previously described . Their framework was based on four elements: (1) theories of learning, (2) generic mobile environment, (3) mobile learning contexts, (4) learning experience and objectives. Theories of learning relate to pedagogical paradigms, generic mobile environment is focused on learners, context focus space, and the authors highlight usability and engaging to describe learning experience and objectives. The framework is divided into two areas: one related to individual skills acquisition and the other for collective learning. Figure 27. A framework for mobile learning design requirements for lifelong learning (Nordin et al., 2010, p. 136)27 shows the mobile learning design requirement framework for lifelong learning. The four dimensions of the framework of Nordin et al. (2010) are the theories of learning (pedagogical) generic mobile learning environment (learner), context, technological, and learning experiences and objectives (outcome).

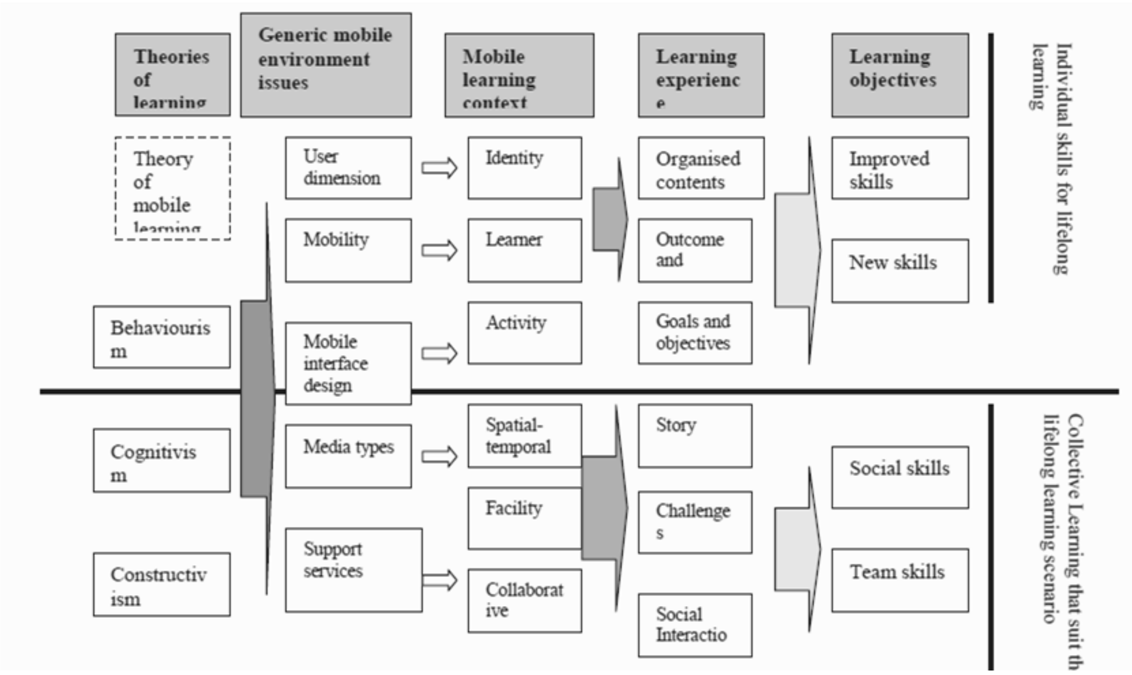


Figure 27. A framework for mobile learning design requirements for lifelong learning (Nordin et al., 2010, p. 136)

Four types of mobile learning: a pedagogical framework *(Park, 2011)*

Park (2011) developed a framework based on the activity theory framework (Jonassen, 2000; Jonassen & Rohrer-Murphy, 1999). The framework defined four types of mobile learning based on two dimensions: transactional distance and social. The transactional distance is defined as a psychological gap between instructor and learner, social dimension connotes "individual versus collective" activities. Figure 28.Mobile learning: A pedagogical framework (Park, 2011, p. 6)28 shows the two dimensions and the positioning of the four types of mobile learning. The two dimensions of the framework of Park, (2011) transactional distance and social.

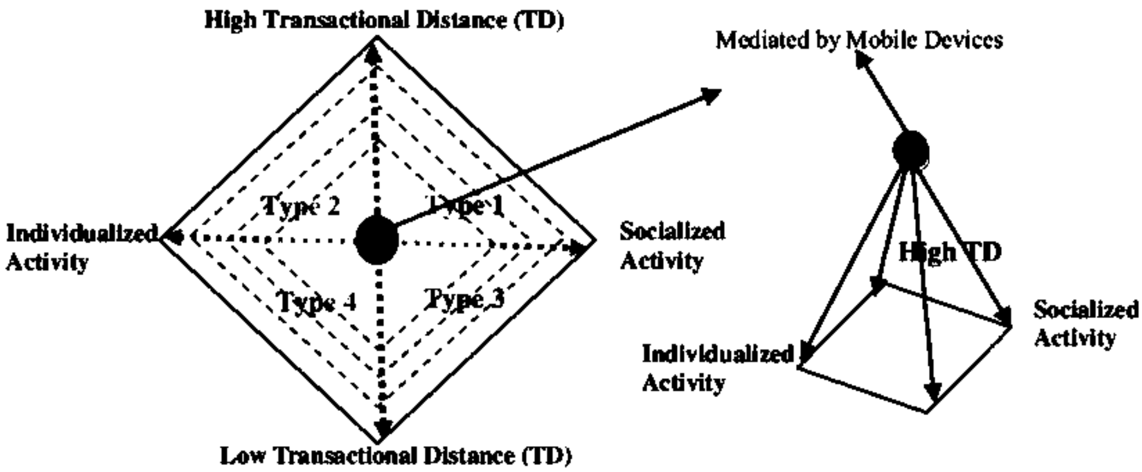


Figure 28.Mobile learning: A pedagogical framework (Park, 2011, p. 6)

The four in balance monitor *(Brummelhuis & van Amerongen, 2011)*

The Four in Balance model is the product of successive scientific contributions (Stichting ICT op School, 2001, Stichting ICT op School, 2004, Kennisnet, 2012). The model has provided positive results in the implementation of ICT in Dutch educational institutions. The pillars on which the model is based are vision, expertise, digital learning materials and ICE infrastructure. These elements driven by leadership and derived from collaboration drive the pedagogical use of technology for learning and consequently improve the quality of education.

Figure 29. The basic elements of the four in Balance model (Brummelhuis & van Amerongen, 2011, p. 25). Figure 29 shows the framework. The dimension of Brummelhuis and van Amerongen (2011) framework are vision, expertise, digital learning materials, ICE infrastructure.

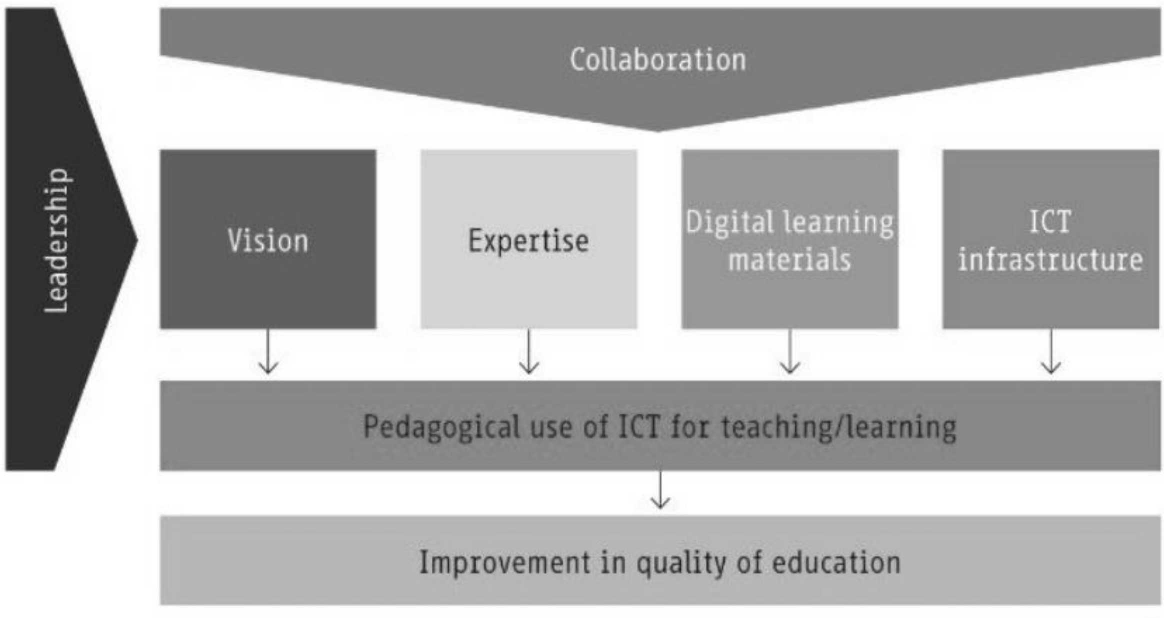


Figure 29. The basic elements of the four in Balance model (Brummelhuis & van Amerongen, 2011, p. 25)

Current framework comprising three distinctive characteristics of m-learning experiences (Kearney et al., 2012)

The framework developed by Kearney et al. (2012) aims to put the pedagogical perspective before the technology, the perspective of socio-cultural theory. The framework is rooted in three construct mobile learning characteristics: authenticity, collaboration, and personalization. Each of these elements is divided into two. Mobile learning experiences can be customized at tool and activity level, consequently, the two sub-scales are agency and customization. Authenticity refers to "the learner-perceived relations between the practices they are carrying out and the use-value of these practices" (Barab & Squire, 2004). Based on the two models of authentic learning: simulation and participation, they used two sub-scales: contextualization and situatedness. The third element is collaboration, the study cited Vygosky (1978) to refer to collaboration as social interaction, conversation and dialogue are fundamental to learning from a socio-cultural perspective as people engage in negotiating to mean and used two sub-scales: conversation and data sharing. The framework was tested in 30 scenarios. Figure 30. Current framework comprising three distinctive characteristics of m-learning (Kearney et al., 2012, p. 21)
30 depicts the framework.

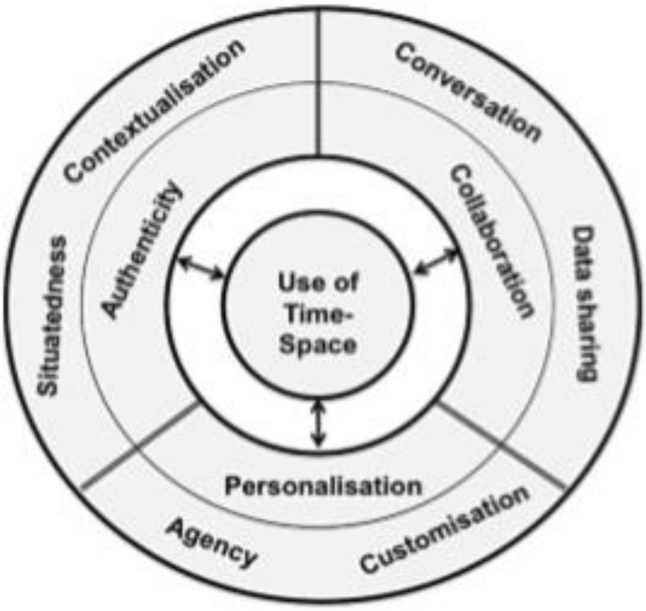


Figure 30. Current framework comprising three distinctive characteristics of m-learning (Kearney et al., 2012, p. 21)

The three dimensions of Kearney et al. (2012) framework is: personalization, authenticity, and collaboration.

A Mobile Design Framework for Continuous Mobile learning Environment in Higher Education (Veerabhadram et al., 2012)

This framework is focused on mobile learning applications and is based on the previously described Liu et al. (2008) framework and activity theory which is based on three learning features, namely, a subject (learners), and objects (the task or activity) and tools (M. Cole et al., 1978). The framework was specifically for Black Berry mobile, to be used among Vaal University of Technology students and the aim was designing mobile learning environments (Figure 31). The design and the role of different academic tools (Veerabhadram et al., 2012, p. 6)1 depicts the framework. The four principal dimensions of Veerabhadram et al. (2012) framework is: device, communication, face-to-face and academic mobile application.

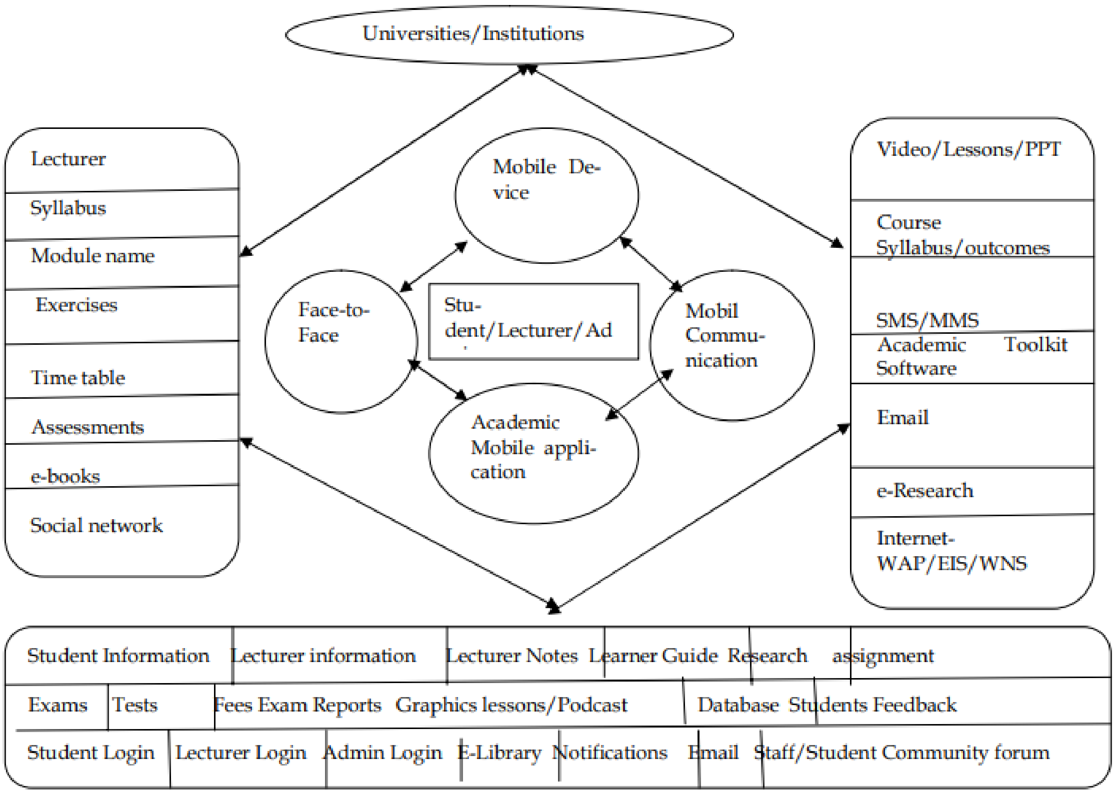


Figure 31. The design and the role of different academic tools (Veerabhadram et al., 2012, p. 6)

Mlearning Scaffolding Five-stage Model (Lim Abdullah et al., 2013)

The model is based on the zone of proximal development learning theory (M. Cole et al., 1978) bridged by 'scaffolding' as the central theme of learning. Vygosky described the zone of proximal development as "the distance between the actual developmental level as determined by individual problem-solving and the level of potential development as determined through problem- solving under adult guidance or in collaboration with more capable peers" (Vygosky, 1978, p. 86). In this zone social interaction is crucial to develop learning, the assistance given by adults or more skilled peers is what later studies call "scaffolding". Figure 32. Zone of proximal development learning theory (Adapted from M. Cole et al., 1978)

Figure 32 shows this model. The four main dimensions of Lim Abdullah et al. (2013) framework is technological, social, context, pedagogical.

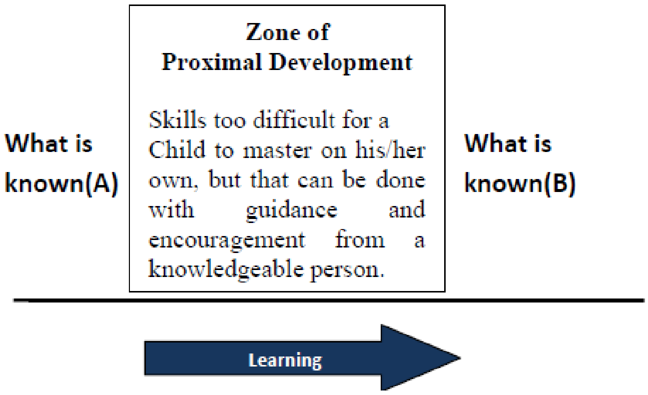


Figure 32. Zone of proximal development learning theory (Adapted from M. Cole et al., 1978)

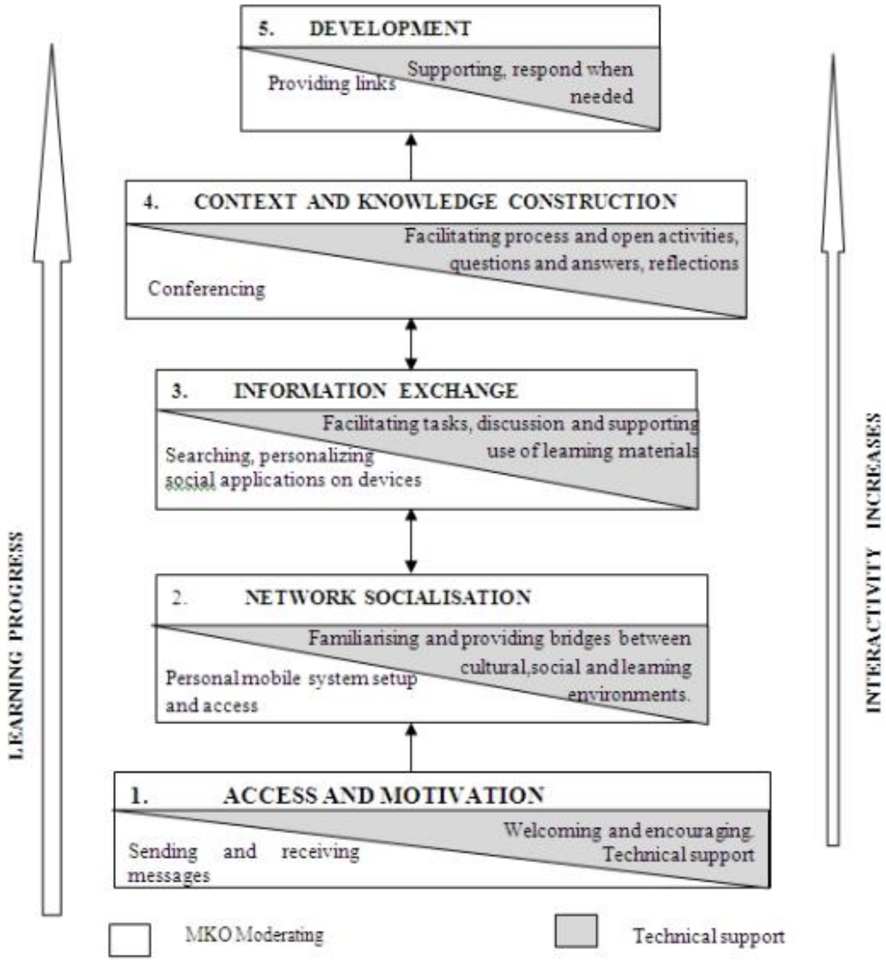


Figure 33. Mlearning M-learning Scaffolding Five-stage Model (Lim Abdullah et al., 2013, p. 221)

Person-centered sustainable model for mobile learning *(Ng & Nicholas, 2013)*

Ng and Nicholas (2013) developed a framework with the aim of developing a model of sustainability for mobile learning that integrates multiple factors. Their framework took a holistic view on how to ensure sustainable mobile learning practice by having the stakeholders work together under inclusive and communicative leadership. Their framework was based on the framework for the sustainability of information and communication technology (ICT) in education (Cisler, 2002). This model has four elements for sustainability: economic sustainability, social sustainability, political sustainability, and technological sustainability. Economic sustainability refers to investment and maintenance of technological resources. Social sustainability addresses educational community involvement. Political sustainability is related to the role of leadership to adopt mobile learning (providing resources, human resources and manage the change process). Ng and Nicholas (2018) added a fifth dimension: pedagogical sustainability, "referred to the teaching and learning practices that support the long-term goals of mobile learning programs" (Ng & Nicholas, 2013, p. 698). Another key concept that inspiring this framework is Intelligent tutoring and adaptive learning, consists of customizing support for students based on their learning status and personal factors (Mampadi et al., 2011).

Among the stakeholders (students, teachers, parents, leadership, and community), Ng and Nicholas argued that teachers are central to the success and sustainability of mobile learning. The authors included in the community group: suppliers, policymakers, software developers and researchers. One of the characteristics is that is not hierarchical, all players interact with no hierarchical relationship. The study also refers to the stakeholders as players the framework indicates the relationships between players in a mobile learning program and the levels of intersection (interactions) between them and with the technology, highlighting the importance of communication, support and trust between stakeholders. The five elements identified (economic, social, political, technological, and pedagogical) are manifested in the interactions between stakeholders. The proposed framework described the interactions between stakeholders and technology Figure 34. Person-centred sustainable model for mobile learning (Ng & Nicholas, 2013, p. 699) The model was tested in three years of research in an Australian school focus on analysing the relationship between stakeholders. Ng and Nicholas framework (2013) was based on five dimensions: technological, social, political, pedagogical, and economic. The authors place the strength of the model in the relationships between the different stakeholders: teachers, students, leadership and management, parents, and wider community (suppliers, policymakers, software developers, and researchers).

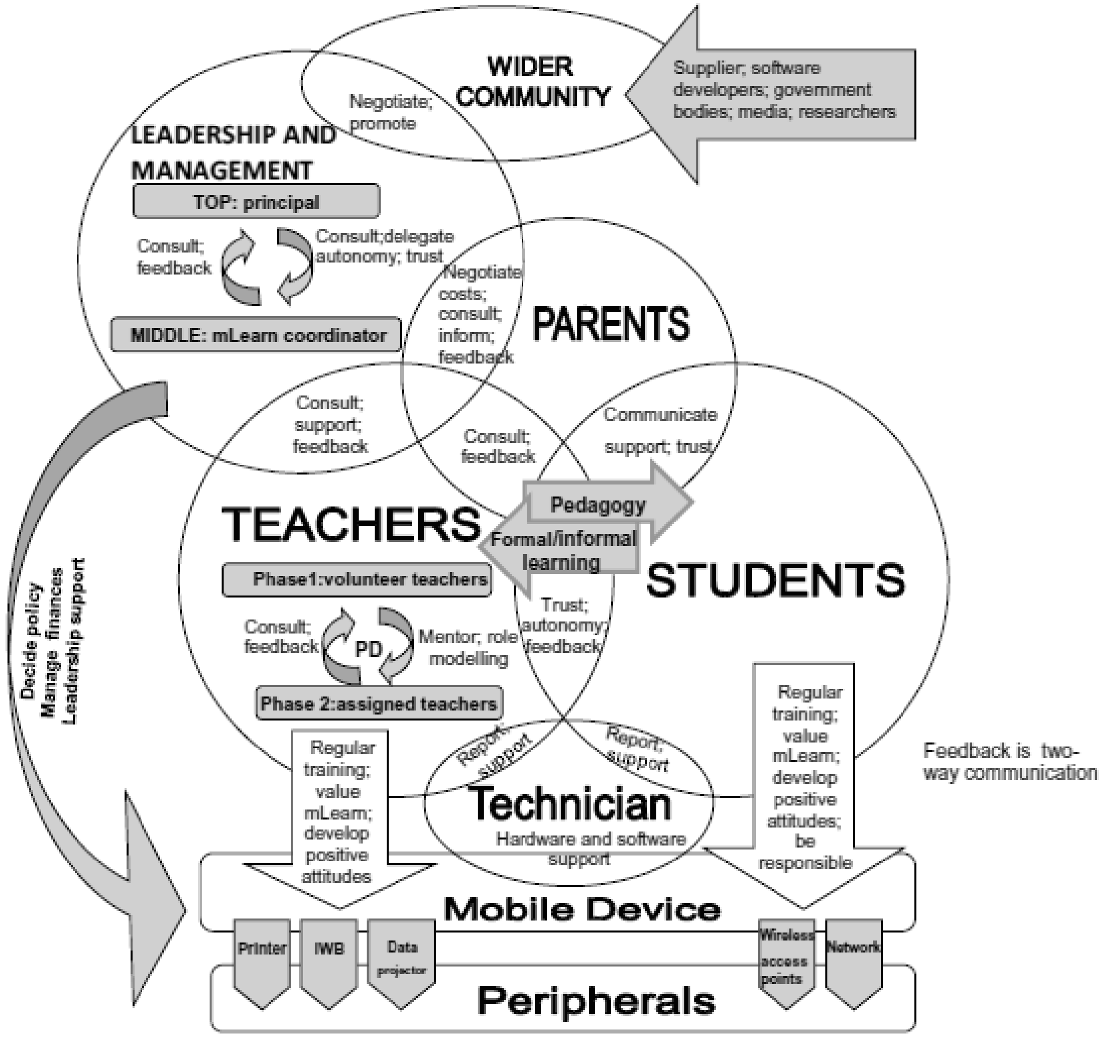


Figure 34. Person-centred sustainable model for mobile learning (Ng & Nicholas, 2013, p. 699)

Framework of a smart learning environment *(Hwang, 2014)*

Hwang (2014) developed a framework for designing and developing smart learning environments to support online and real-world learning activities, from the perspective of context-aware ubiquitous learning. The author refers to the concept of smart learning as an evolution of context-aware learning, a learning approach that employs mobile, wireless communication and sensing technologies such as GPS (Global Positioning System), RIFD (Radio-Frequency Identification) and QR (Quick Response). Other technologies such as Augmented Reality (AR), computer vision and speech recognition also contribute to developing smart environments. AR is a technology that allows learners to see real-world and digital-world information in an integrated mode (Dunleavy et al., 2009). Hwang (2014) identified the following distinctive features of smart learning: detects and takes into account the real-world contexts; situates learners in real-world scenarios; adapts learning content for individual needs; adapts learning interface for individual learners; adapts tasks and objectives for individual learners; provides personalized feedback or guidance; provide learning support across disciplines; provides learning support across contexts; recommends learning tools or strategies; considers the online learning status of learners; considers the real-world learning status of learners; facilitates both formal and informal learning; takes multiple personal factors and environmental factors; interacts with users via multiple channels and provides support across real and virtual contexts.

Smart digital environment is defined as "an environment that enables learners to access to digital resources and interact with learning systems in any place, at any time and actively provides the necessary learning guidance, hints, supportive tools or learning suggestions to them in the right place, at the right time and in the right form (Hwang, 2014, p. 2). Figure 35. Framework of smart learning environment (Hwang, 2014, p. 7)35 shows the framework. Hwang (2014) identified six modules in his framework: learning performance and environment context, learning performance evaluation module, adaptative task module (based on learning performance), adaptive learning content module, personal learning support module and databases for keeping the learner profiles (learning portfolios, learning materials, learning tools). Personalisation is a key feature in Hwang's framework. Identify learner needs based on context, customize evaluation, content, tasks, and support, and build a personalized learning portfolio. Tailor-made education with multiple resources and in multiple social scenarios (real or virtual).

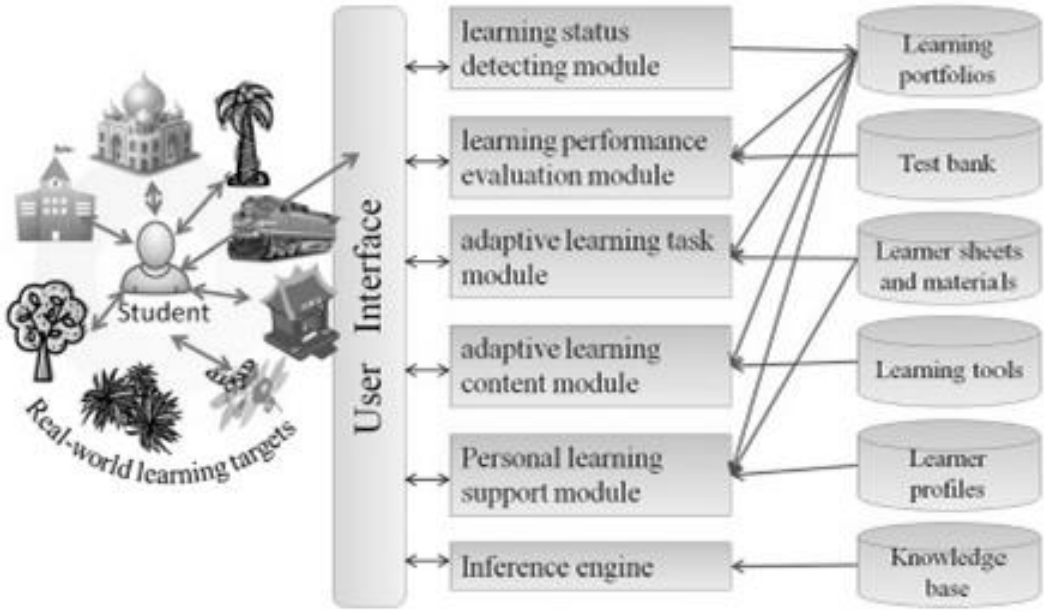


Figure 35. Framework of smart learning environment (Hwang, 2014, p. 7)

Framework Model of Mobile Learning Application (Khalid et al., 2015)

The framework is oriented to develop a mobile learning application of a specific software: "Jamak Qasar Apps". The main purpose is to stimulate and maintain the user's motivation. The framework is based on two design methodologies, on the one hand, the ARCS model of motivation design (Keller, 1983) and on the other hand ADDIE model. The ADDIE model is a framework that lists generic processes that instructional designers and training developers use which represent a guideline in designing and developing educational and training programs. in five phases: analysis; design; development; implementation and evaluation. ARCS model contains steps for promoting and sustaining motivation: attention, relevance, confidence, and satisfaction. Khalid et al.'s (2015) framework dimensions are strategic elements, environment, pedagogical and technological (Figure 36). The framework is oriented to instructional designers and educators and the main purpose is to maintain and sustain motivation among users.

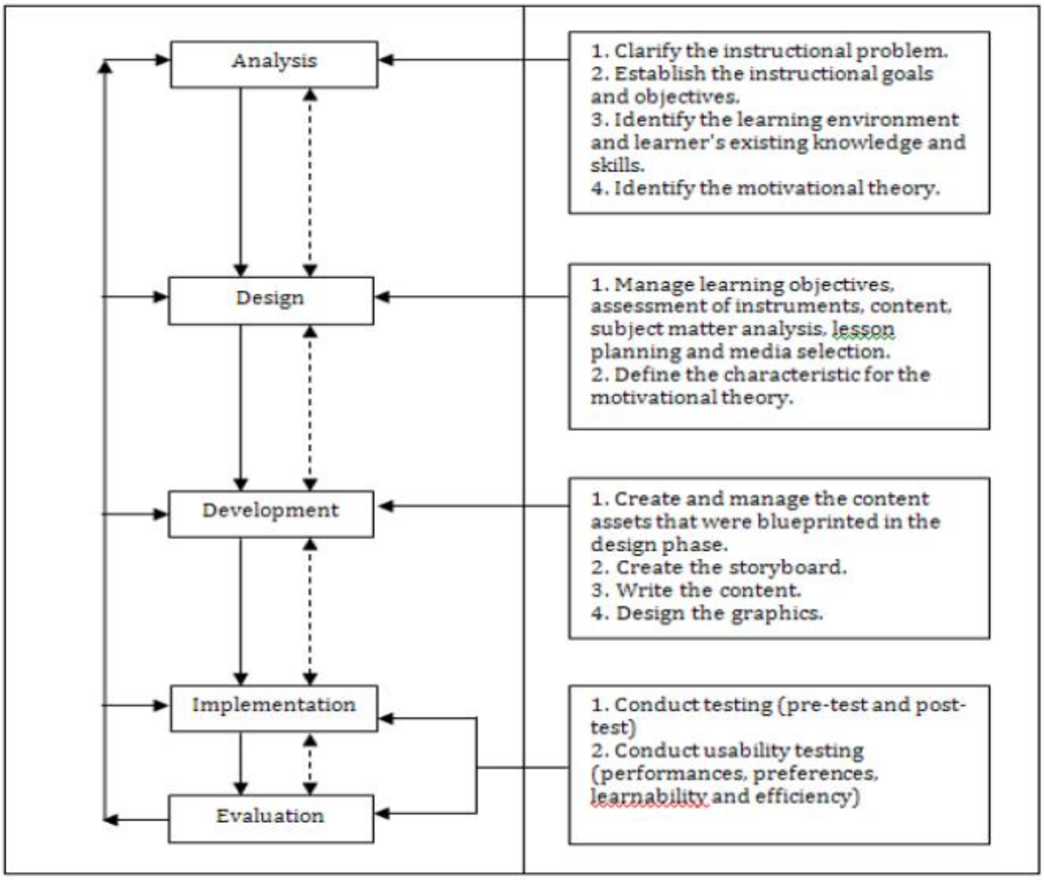
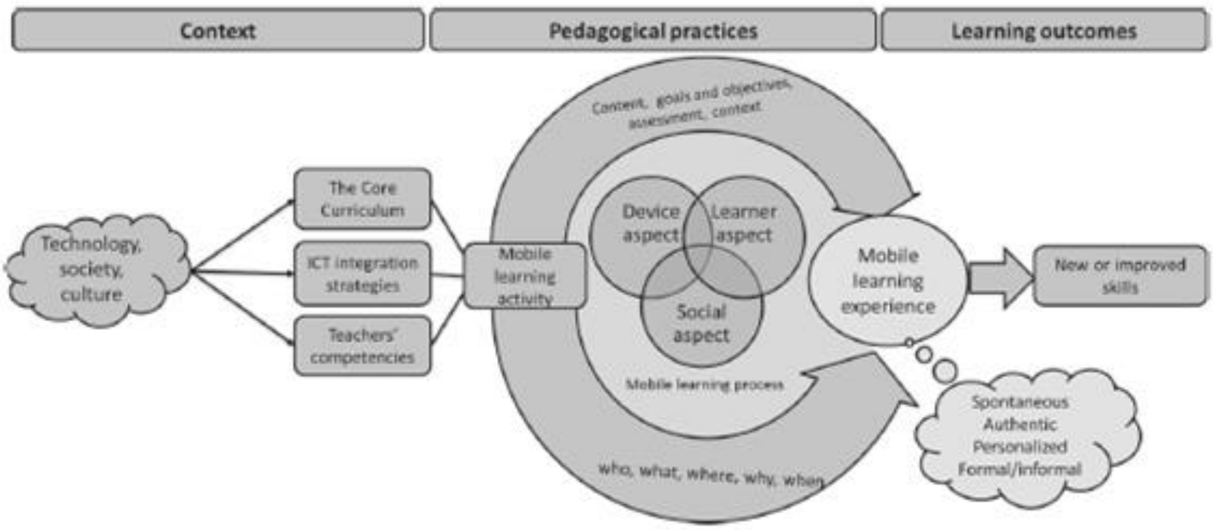


Figure 36.Framework model of mobile learning application (Khalid et al., 2015, p. 42)

Mobile learning framework (Rikala, 2015)

An initial version of Rikala (2015)'s framework was developed based on two frameworks previously analysed, Koole (2009) and Kearney et al. (2012). This version consists of two levels, the core and medium level. Core level includes context, time and scarce aspects and the medium level covers the learner, device and social Koole's elements (Rikala, 2014). The author tested this initial framework through four case studies and found that medium aspects were realized comparatively well but core level aspects, were more challenging. Highlighting the importance of the pedagogical aspects and found out other aspects that were not covered by the initial framework, such as teacher's competencies, ICT integration strategies and technological, social, and cultural changes. The author refines and developed the mobile learning framework shown in Figure 37. Mobile learning framework (Rikala, 2015, p. 160)
37. The main constructs of this framework are pedagogy, context (curriculum, implementation strategies and teacher's competencies), learner, device, and social



interactions.

Figure 37. Mobile learning framework (Rikala, 2015, p. 160)

Designing a framework for mobile learning adoption and sustainable development

Resources, Activity, Support and Evaluation (Churchill et al., 2016)

The authors described the framework as a pedagogical student-centered learning model. The model has four components: resources, activity, support, and evaluation. The model builds upon theoretical concepts such as constructivist learning environments, problem-solving, engaged learning, problem-based learning, rich environment learning for active learning, technology-based learning environments, interactive learning environments, collaborative knowledge building and situated learning.

The framework aims to provide insights to teachers to achieve learning outcomes. Specifically, the study suggested that in addition to *resources*, teachers need to consider: *activity* for students to engage in using resources and working on tasks such as experiments and problem solving leading through experience; *support* to ensure that students are provided help, and where possible with tools to independently or in collaboration with other students solve emerging difficulties; and *evaluation* to provide structured information to guide students' progress. Figure 38 shows RASE framework. The four dimensions of Churchill et al., (2016)'framework is: resources, activity, support and evaluation.

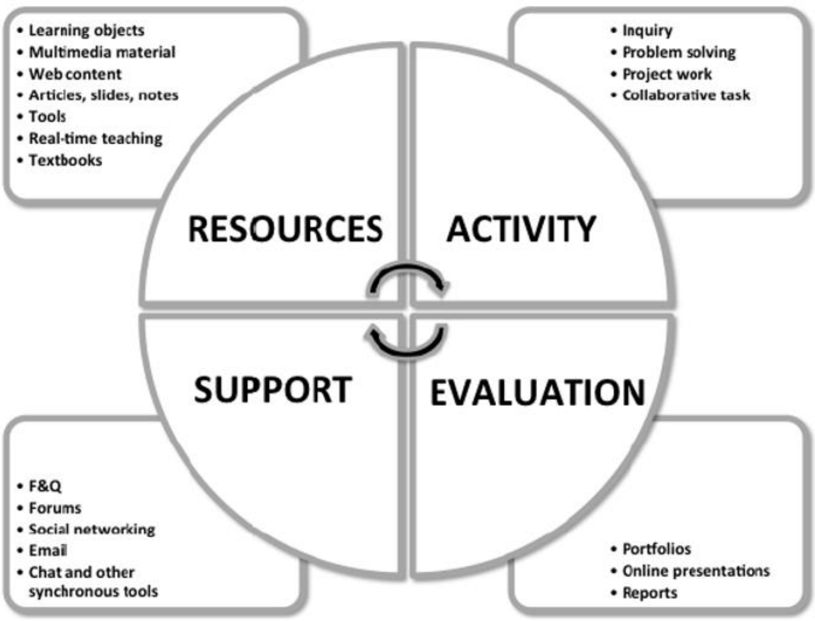


Figure 38. Resources, Activity, Support and Evaluation (Churchill et al., 2016, p.140)

Mlearning integration ecological framework (Crompton, 2017)

The framework was based on four categories obtained from a systematic analysis: beliefs that included the role of teacher, socio-cultural influences, self-efficacy and past experience; resources that included training, technical support and access to technology; methods including online/face-to-face, methodology e.g. constructivism; and purpose this includes time-filler/understanding of concepts, level of the technology makes a difference. "Each part encompasses multiple sub-parts which are interacting, interrelated, and/or interdependent elements that need to be considered for an educator to effectively integrate technology" (Crompton, 2017, p. 11). The framework represented the influence of social and environmental factors in a mobile learning integration ecological framework (Figure 39. . A cognitive knowledge/based framework for social and metacognitive support in mobile learning (Crompton, 2017, p. 109)

According to Crompton (2017) the constructs of mobile learning are pedagogies, context, social interactions, and technological devices. She provided subcategories for each dimension and contextualized in a framework representing social and environmental influence. The framework was aimed to support educators.

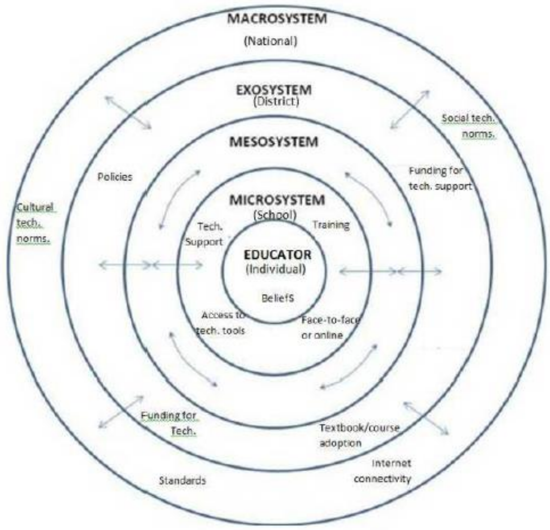


Figure 39. . A cognitive knowledge/based framework for social and metacognitive support in mobile learning (Crompton, 2017, p. 109)

Mobile learning Framework for Assessment Feedback *(Ada, 2018)*

This model is very focused on the assessment; however, was included in this research, due to the consistency with the rest of the frameworks analyzed. The framework developed by Ada (2018), structure in three areas: needs assessment, development /implementation, and outcomes. The central part of the study, development and implementation was based on four core aspects: ownership, pedagogy, context, and ICT infrastructure. The author referred to ownership “is about students reclaiming control over the devices that suit their taste or convenience and suit the time they want to access their content, where they want to access that content and the pace at which they interact with it. It is about student motivation and being in control of their choices in a student-centered environment” (Ada, 2018, p. 8). The model is based on a student-centered environment where students are empowered to make their own learning decisions (Figure 40).

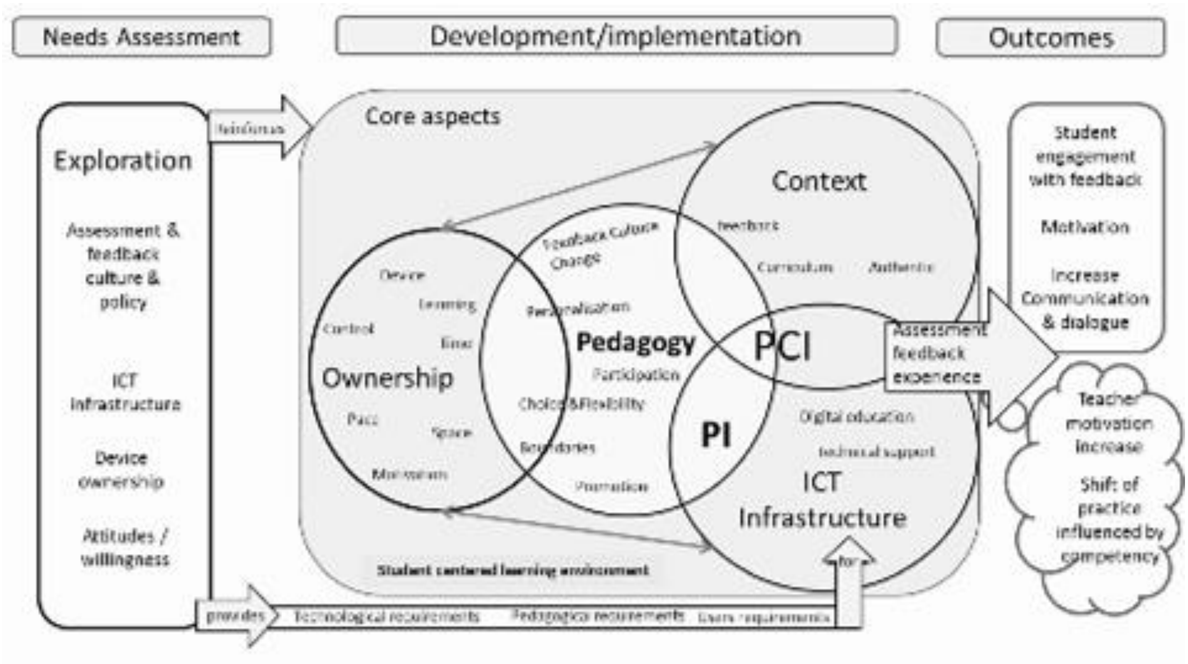


Figure 40. Mobile learning Framework for Assessment Feedback (Ada, 2018, p. 15)

4.2. Dimensions of mobile learning theoretical frameworks

A thematic synthesis (Thomas et al., 2012) was conducted to analyse the principal framework dimensions. Thematic synthesis is suitable for analysis to bring together researchers from different sources to offer a common understanding. The thematic synthesis requires applying thematic codes across studies using an inductive and deductive process. The process is based on three phases: first, is to gather the information and coding the studies, the second phase includes to the organization of the codes "to develop and articulate relationships between the themes and associate conceptually similar themes with one another" (Thomas et al., 2012, p. 196), the third phase relates to creating new conceptualizations.

For the *first phase* of Thomas's model, similar or prior codifications related to modified dimensions have been sought in the processes of development of frames for mobile learning.

Some of the models analysed are based on previous pedagogical frameworks such as activity theory or zone of proximal development (Vygosky, 1978) described above.

From the above analysis, this study identified certain commonalities in the dimensions of mobile learning frameworks that root in multi-disciplinary fields. Each study shows certain dimensions with different intensities, depending on the approach. Most studies have an orientation towards instructional design, design of specific activities, learning experiences and learning environmental design. some others focus on the acquisition of skills and only a few of them are in the process of adopting mobile learning from a broader spectrum. In line with these guidelines, the studies are aimed at educators, researchers, instructional designers, policymakers, IT responsible and school leaders.

L. H. Wong & Looi (2011) based on a systematic review, suggested ten dimensions characterizing activities for mobile-assisted learning (MLS): (MSL1) Encompassing formal and informal learning; (MSL2) Encompassing personalized and social learning; (MSL3) Across time; (MSL4) Across locations; (MSL5) Ubiquitous access to learning resources (online data and information, teacher-created materials, student artifacts, student online interactions, etc.); (MSL6) Encompassing physical and digital worlds; (MSL7) Combined use of multiple device types (including "stable" technologies such as desktop computers, interactive whiteboards); (MSL8) Seamless switching between multiple learning tasks (such as data collection, analysis, and communication); (MSL9) Knowledge synthesis (a combination of prior and new knowledge, multiple levels of thinking skills, and multi-disciplinary learning); (MSL10) Encompassing multiple pedagogical or learning activity models. Other studies identified mobile learning characteristics: Klopfer et al. (2002): portability, connectivity, social interactivity, individuality, and merging digital and physical worlds. Traxler (2010, p.15): “everyone can produce content to learn, and everyone one can discuss it anywhere/anytime and just-in-time, just-for-them”. (Khaddage et al., 2016): individualized, learner-cantered, situated, collaborative, ubiquitous, and continuing, so has the technology. The dimensions are also consistent with some of the frameworks reviewed in this research. Burris (2017) integrated the framework for mobile learning experiences (Kearney et al., 2012) with Wong (2011) mobile learning dimensions. Condensing and regrouping some of the dimensions in higher categories. The dimension identified by Kearny et al. (2012) as the authenticity that was unfolded in situatedness and answering, encompasses the dimensions identified by Wong (2011) of formal and informal learning, the combination of multiple tools and support of multiple pedagogies.. Hsu & Ching (2015) conducted a review of models and frameworks for designing mobile learning experiences. The study annualized 17 papers and classified them into five categories: (1) pedagogies and learning environment design; (2) platform/system design; (3) technology acceptance; (4) evaluation; and (5) psychological construct. Based on relationships, the dimensions synthesized in four upper categories: pedagogical; collaboration, social and communication; environment and context and technological shown in the sixth column of the table. Table 22 shows the relationship between the different dimensions and proposes a new codification.

Table 22. Dimensions of mobile learning

L. H. WONG & LOOI (2011)	KLOPFER, SQUIRE, & JENKINS, (2002)	TRAXLER (2010, P.15)	KHADDAGE, MÜLLER, & FLINTOFF, 2016)	DIMENSIONS BURRIS WITH KEARNEY ET AL. 2012	HSU & CHING (2015)	PROPOUSED DIMSIONS
Encompassing formal and informal learning				Authenticity (situatedness and contextualisation)	Pedagogies and learning environment design	Pedagogical
Encompassing personalized and social learning	Individuality Social interactivity	Just for them	Individualized	Collaboration (conversation and data sharing)	Pedagogies and learning environment design	Collaboration/social/communication
Across time		Anytime		Use of time and space	Pedagogies and learning environment design	Pedagogical
Across locations	Portability	Anywhere	Ubiquitous	Use of time and space	Pedagogies and learning environment design	Environment and context
Ubiquitous access to learning resources		Just in Time		Use of time and space	Pedagogies and learning environment design	Environment and context
Encompassing physical and digital worlds	Merging digital and physical worlds	Situated	Use of time and space	Manage spaces, environment	Platform/system design	Environment and context
Combined use of multiple device types				Authenticity (situatedness and contextualisation)	Platform/system design	Technological
Seamless switching between multiple learning tasks	Connectivity	Everyone can produce learning	Learner - cantered	Personalisation, agency, and customisation	Pedagogies and learning environment design/evaluation	Pedagogical
Knowledge synthesis				Personalisation, agency, and customisation	Pedagogies and learning environment design	Pedagogical
Encompassing multiple pedagogical or learning activity models			Authenticity (situatedness and contextualisation)	Pedagogical		Pedagogical

Although there are consistencies in the dimensions identified in the 20 frameworks analysed, each model uses a different terminology and is aimed at a different audience and focus on different purposes. Table. 23 shows the main dimensions of each framework, as well as the educational use to which they are oriented and the main target.

Table 23. Dimensions of mobile learning frameworks

STUDY	FRAMEWORK/MODEL	DIMENSIONS	PURPOSE OF USE/TARGET
Mishra & Koehler (2006)	Technological Pedagogical Content Knowledge (TPACK)	Technological, pedagogical, and content	Acquisition of the necessary skills in teachers
Motiwalla (2007)	A m-learning framework	Pedagogical (personalization), social and collaborative	Activity design/Educators, instructional designers
H. Liu et al., (2008)	Design framework for mobile learning	Users requirements (pedagogical), scenario, technology, and learner support	Activity design/ Educators/ Instructional designers
Peng et al. (2009)	The conceptual framework of ubiquitous knowledge construction	Tools (technology) , mobile learner, and pedagogical	Mobile learning adoption
Koole (2009)	The framework for the rational analysis of mobile education (FRAME)	Device, learner, pedagogical, and social	Development of learning materials (Instructional design), mobile learning adoption / Educators
Vavoula and Sharples (2009)	M3 evaluation framework	Technological, pedagogical, and social	Mobile learning design and evaluation/ educators, instructional designers
Puentedura (2009)	Situation, augmentation, modification, redefinition	Pedagogical, technological	Mobile learning adoption/educators, instructional designers
Nordin et al. (2010)	A framework for mobile learning design requirements for lifelong learning	Pedagogical , generic mobile learning, technological, environment (learner), context, and learning experiences, and objectives (outcome)	Applications and design/Instructional designers
Park (2011)	Four types of mobile learning: a pedagogical framework	Transactional distance, and social	Design activities/Instructional design
Brummelhuis and van Amerongen (2011)	The four in balance monitor	Expertise, digital learning materials, and ICE infrastructure	Mobile learning adoption/leadership
Kearney et al. (2012)	Current framework comprising three distinctive	Personalization, authenticity, and	Design of mobile learning experiences and

	characteristics of m-learning experiences	collaboration	resources/researchers and practitioners
Veerabhadram et al. (2012)	A Mobile Design Framework for Continuous Mobile learning Environment in Higher Education	Device, communication, face-to-face and academic mobile application.	Design mobile learning environments/Instructional designers, educators, learners, school leaders
c et al. (2013)	Mlearning Scaffolding Five-stage Model	Technological, social, context, pedagogical	Describe learning process/mobile learning adoption /School leaders, instructional designers
Ng and Nicholas (2013)	Person-centered sustainable model for mobile learning	Technological, social, political, pedagogical, and economic	Mobile learning adoption/ teachers, students, leadership and management, parents, and wider community
Hwang (2014)	Framework of a smart learning environment	Learner and context status, customize evaluation, content, tasks, support, personalized learning portfolio	Design smart learning environments/ researchers, learners, developers, and teachers.
Khalid et al. (2015)	Framework Model of Mobile Learning Application using ADDIE Approach	Strategic elements, environmental context, pedagogical, technological,	Design mobile learning applications/(Educators, instructional designers
Rikala (2015)	Mobile learning framework	Pedagogy , context (curriculum, implementation strategies and teacher's competencies), learner, device, and social interactions.	Planning, implementing and evaluating/education practitioners.
Churchill et al. (2016)	Resources, activity, support, and evaluation	Resources, activity, support, and evaluation	Design activities/Instructional designers, learners, educators
Crompton (2017)	Mlearning integration framework	Pedagogies, context, social interactions, and technological devices	Mobile learning adoption /educators
Ada (2018)	Mobile Learning Framework for Assessment Feedback	Context, pedagogy, ICT infrastructure, communication, and dialogue	Mobile learning assessment feedback/educators, policymakers, learners, and researchers.

Designing a framework for mobile learning adoption and sustainable development

There is a huge consensus on the inclusion of the pedagogical dimension in a mobile learning framework. All frameworks specifically referred to it. Theories of learning play an important role in all frameworks analysed. Two dimensions are common to all the analysed frameworks: pedagogical and technological. Mortimore (1999) defined pedagogy as 'any conscious activity by one person to enhance learning in another' (p. 17). Although mobile learning can be framed in different pedagogical approaches, constructivism is the most cited. "Mobile learning can support every pedagogic option, including the didactic and the discursive, the individual and the social" (Traxler, 2010, p. 15).

Constructivist learning laid the foundations for the development of innovative student-centred approaches (Baeten et al., 2010). Cannon & Newble (2000) described the student-centred approach as "ways of thinking about teaching and learning that emphasise student responsibility and activity in learning rather than content or what the teachers are doing" (p.17).

Five frameworks analysed are developed on the central role of the student (Ada, 2018; Churchill et al., 2016; Hwang, 2014; Ng & Nicholas, 2013; Veerabhadram et al., 2012).

Baeten et al. (2010) conducted a detail literature review about student-centred learning and identified the following characteristics: (1) an activity and independence of the student, (2) a coaching role of the teacher, and (3) knowledge which is regarded as a tool instead of an aim.

Hamidi (2018) developed a comparison between teacher-centred and student-centred approaches in educational based on five indicators: preferred teaching method, instructor role, learner's role, learning style and learning outcomes. Table 24 reproduces a summary of the Study.

Table 24. Comparison between teacher-centred and student-centred approaches in educational settings (Adapted from S. Hamidi, 2018)

	TEACHER-CENTERED	LEARNER -CENTERED
Preferred teaching method	Lecture	Lecture, large/small group discussion
Instructor role	Active role: directs learning, source of knowledge, clarifies and interprets	Facilitator/coaching role promotes dialogue, demonstrate skills
Learner's role	Passive role: listen, take notes, read, memorize, demonstrate memorization thought testing	Active role: critical thinking, express opinion, demonstrate understanding, self - assessment. Learner ownership and agency
Learning style	Top-down, knowledge base	Competency-based, cooperative, participatory, interactive. Based on values respect, care and empathy, positive relationships
Learning outcomes	Memorize and absorb knowledge	Gain knowledge, apply concepts to real situations, use critical/analytical skills

The characteristics and features of mobile learning described above of ubiquity and mobility, accessibility, situatedness and contextualization, immediacy, engagement, personalization, social connectivity and interactivity, collaboration, technological; empower the distinctive features of student-cantered learning. The second phase of the thematic synthesis includes to the organization of the codes “to develop and articulate relationships between the themes and associate conceptually similar themes with one another” (Thomas et. al., 2012, p.196). One code was added to the four codes identified in the first phase of the research: strategic elements, referred to set goals, mission, values, resources’ management, leadership commitment, communication, and support from the educational instructions. Consequently, the five dimensions considered in this study are pedagogical; technological; social, communication and collaborative; environment and context; and strategic elements. The 20 studies analysed were classified into those five dimensions. The classification has been made by the two researchers and reviewed by a third expert. Table 25 shows teethe classification of the dimensions identified in each study according to the coding proposed in this study.

Table 25. . Mobile learning frameworks 'dimensions

DIMENSION/SUBDIMENSION	STUDY
Collaboration/social/communication	
Collaboration	Kearney et al. (2012)
Communication	Veerabhadram et al. (2012)
Communication and dialogue (asynchronous/synchronous)	Ada (2018)
Moderating (social interaction)	Lim Abdullah et al. (2013)
Social	Crompton (2017),Koole (2009),Ng and Nicholas (2013),Park (2011),Vavoula and Sharples (2009),
Social and collaborative	Motiwalla (2007)
Social interactions.	Rikala (2015)
Environment and context	
Authenticity	Kearney et al. (2012)
Content	Mishra & Koehler (2006)
Context	Crompton (2017),Nordin et al. (2010)
Context (curriculum, feedback)	Ada (2018)
Context (curriculum, implementation strategies and teacher's competencies)	Rikala (2015)
Environmental/ context	Khalid et al. (2015)
Generic mobile learning environment (learner/collective)	Nordin et al. (2010)
Learner	Koole (2009),Rikala (2015)
Learner and context status	Hwang (2014)
Mobile learner	Peng et al. (2009)
Scenario	H. Liu et al., (2008)
Technical support	Lim Abdullah et al. (2013)
Users requirements (pedagogical)	H. Liu et al., (2008)
Pedagogical	
Academic mobile application.	Veerabhadram et al. (2012)
Activity	Churchill et al. (2016)
Customize Content	Hwang (2014)
Customize evaluation	Hwang (2014)
Customize support	Hwang (2014)
Customize tasks	Hwang (2014)
Digital learning materials	Brummelhuis & van Amerongen (2011)
Evaluation	Churchill et al. (2016)
Expertise	Brummelhuis & van Amerongen (2011)
Face-to-face	Veerabhadram et al. (2012)
Learner support	H. Liu et al., (2008)
Learning	Nordin et al. (2010)

Outcome (feedback)	Ada (2018)
Pedagogical	Khalid et al. (2015),Koole (2009),Mishra & Koehler (2006),Ng and Nicholas (2013),Nordin et al. (2010),Peng et al. (2009),Puentedura (2009),Vavoula and Sharples (2009)
Pedagogical (personalization)	Motiwalla (2007)
Pedagogical support and training	Ada (2018)
Pedagogy	Crompton (2017),Rikala (2015)
Pedagogy (participation, personalisation, choice, and flexibility)	Ada (2018)
Personalization	Kearney et al. (2012)
Personalized learning portfolio	Hwang (2014)
Support	Churchill et al. (2016)
Teacher mentor role modelling learning	Ng and Nicholas (2013)
Technical support	Lim Abdullah et al. (2013)
Transactional distance	Park (2011)
Strategic elements	
Political	Ng and Nicholas (2013)
Strategic elements	Khalid et al. (2015)
Vision	Brummelhuis & van Amerongen (2011), Peng et al. (2009)
Technological	
Device	Koole (2009),Rikala (2015),Veerabhadram et al. (2012)
Economical	Ng and Nicholas (2013)
ICT infrastructure	Brummelhuis & van Amerongen (2011)
ICT infrastructure(digital education, technical requirements, technical support)	Ada (2018)
Pedagogical (durable lifelong learning)	Peng et al. (2009)
Resources	Churchill et al. (2016)
Technical support	Lim Abdullah et al. (2013)
Technological	Khalid et al. (2015),Mishra & Koehler (2006),Ng and Nicholas (2013),Puentedura (2009),Vavoula and Sharples (2009),
Technological, media	Nordin et al. (2010)
Technologies facilitating smart learning (GPS, RFID, QR, AR and computer vision)	Hwang (2014)
Technology	Crompton (2017),H. Liu et al., (2008)
Tools (technology)	Peng et al. (2009)

All studies analysed to highlight the *pedagogical* dimension. Personalisation has been identified in four different frameworks (Hwang, 2014; Kearney et al., 2012; Nordin et al., 2010; Park, 2011), other studies refer indirectly including in their theoretical frameworks the needs of the learner (Ada, 2018; Koole, 2009; H. Liu et al., 2008; Rikala, 2015). There are numerous studies highlighting the positive results of the personalization of learning processes (Ferguson, 2011; Taylor & Burke da Silva, 2014). Hwang (2014) delves into the personalization dimension and identifies three types of personalization, content, activities, and support.

Within the pedagogical dimension, four studies refer specifically to evaluation (Ada, 2018; Churchill et al., 2016; Hwang, 2014; Ng & Nicholas, 2013). An approach in evaluation is made by Ng and Nicholas (2013), when they describe one of the teacher's roles as a mentor and modelling students.

Only one model explicitly refers to the training of teachers as part of the pedagogical dimension (Ada, 2018). Essentially, teachers need assistance to be effective at integrating mobile learning, and assistance involves not only learning how to operate the devices but also helping them plan mobile learning activities (Dennen & Hao, 2014, p. 398).

The second most cited dimension in the analysed frameworks is the *environment and context*. The different studies refer to different aspects of the environment and contextualization such as spatial location, temporal dimension, physical and virtual environments, influence of policies, economics, social, legal, technology availability, curriculum, aspects of students and teachers, among others (Ada, 2018; Crompton, 2017; Kearney et al., 2012; Koole, 2009; Lim Abdullah et al., 2013; H. Liu et al., 2008; Mishra & Koehler, 2006; Nordin et al., 2010; Peng et al., 2009; Rikala, 2015). The frameworks seek to contextualize learning in authentic environments which is consistent with other studies that have identified new concepts of learning spaces such as eco-garden, vegetable patch or living laboratories (Ferreira et al., 2014).

Dimensions related to *social, communication and collaborative* environments have been emphasize 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 et al., 2012). Koole (2009) marked that the social aspect considers the processes of social interaction and cooperation.

Most studies include the *technological* dimension in their studies. The authors use different approaches to refer to the technological dimension of their frameworks such as device, tools, technical support or ICT infrastructure (Ada, 2018; Brummelhuis & van Amerongen, 2011; Crompton, 2017; Hwang, 2014; Koole, 2009; Lim Abdullah et al., 2013; H. Liu et al., 2008; Mishra & Koehler, 2006; Ng & Nicholas, 2013; Peng et al., 2009; Puentedura, 2009; Rikala, 2015; Veerabhadram et al., 2012).

Three studies included *strategic elements* on their frameworks (Brummelhuis & van Amerongen, 2011; Ng & Nicholas, 2013; Peng et al., 2009).

The following figure summarizes and quantifies the dimensions used in the analysed frameworks (Figure 41. Mobile learning frameworks dimensions1).

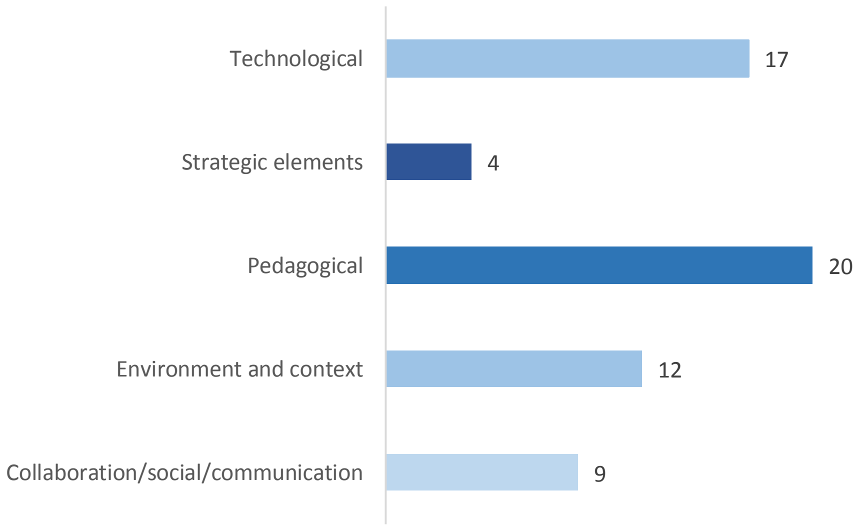


Figure 41. Mobile learning frameworks dimensions

Most of the analysed frameworks are oriented to the adoption of mobile learning (65%), some are specific to the design of activities or learning environments and only one is specifically oriented to the evaluation design.

Figure 42. Mobile learning frameworks purposes2 shows the distribution of the studies analysed.

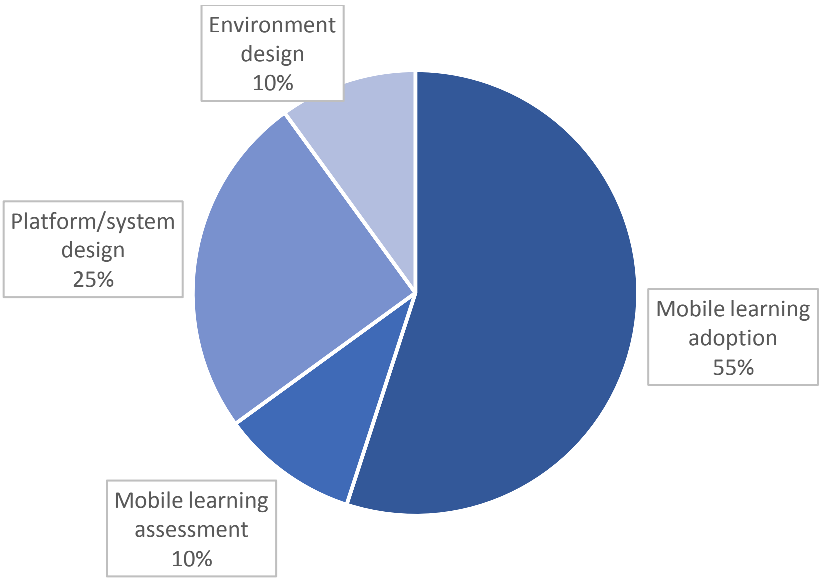


Figure 42. Mobile learning frameworks purposes

Although the most frequent purpose of theoretical frameworks is the adoption of mobile learning, analysing the target audience to which they are addressed, they are mostly oriented to educators and designers . Those findings are consistent with other mobile learning studies about the research purposes reporting that most of the studies focus on designing, developing and implementing mobile learning applications and mobile learning effectiveness (Krull & Duart, 2017; Moya & Camacho, 2020a; 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 the breadth of the participating agents.

Most of the theoretical frameworks for the adoption of mobile learning analysed, have been aimed at educators and instructional designers, it should be noted that very few are family, policymakers and researchers oriented.

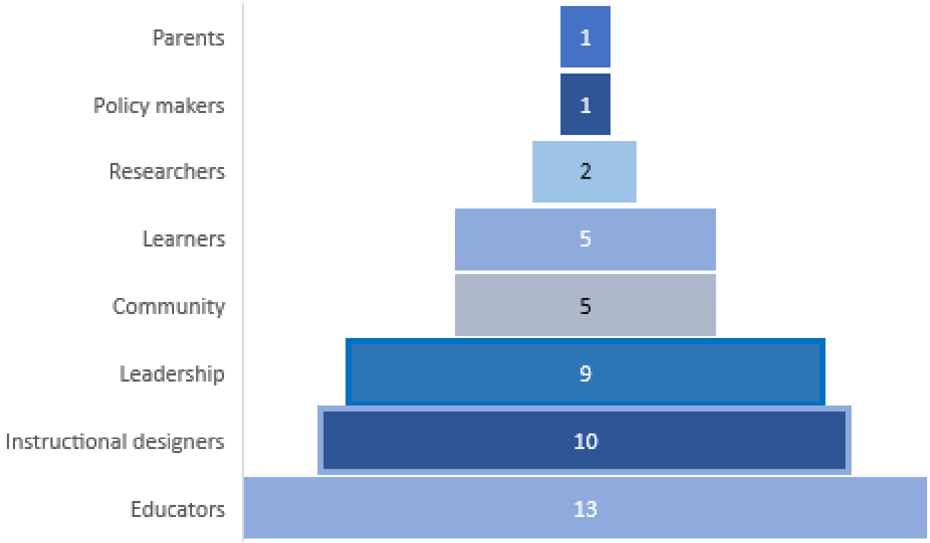


Figure 43. Mobile learning frameworks targets

It's important to highlight that all dimensions are showing separately in an effort of organizing and structuring the study, but they are highly interconnected (Crompton, 2017; Hwang, 2014; Ng & Nicholas, 2013).

4.3. Study 3: "Design principles of mobile learning frameworks"[3]

4.3.1. Introduction

The man objective of this study is to identify the fundamental design principles for the development of a framework for adoption and sustainable use of mobile learning. This study is based on a systematic review of 20 studies containing mobile learning frameworks.

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:

RQ1. What are the most relevant characteristics of the theoretical frameworks used for mobile learning?

RQ 2. What are the main design principles used for the development of frameworks for the adoption and sustainable use of mobile learning?

4.3.2. 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. The process to adapt the methodology was defined by Okoli and Schargram (2010) as "a step-by-step approach to carry out the rigorous and scientific methodology of a systematic literature review".

Search Strategy

The literature search was based on specific concepts (Webster & Watson, 2002). Table 26 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,

[3] Moya, S., & Camacho, M. (2021). Design principles of mobile learning frameworks. International Journal of Mobile and Blended Learning, 13(1).

referring exclusively to the title of the document: all in title: "model" OR "framework" AND "mobile learning" OR "m-learning".

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).

Table 26. Sources consulted and the application of criteria

SOURCE	SEARCH	CRITERIA
SCOPUS	230	15
WOS Web of Science	140	12
Google Scholar	90	17

Inclusion and exclusion criteria

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

(1) Exclude specific applications or functionalities, such as augmented reality.
(2) Exclude articles on the design of highly technical applications or systems.
(3) Exclude studies related exclusively to attitudes and perceptions.
(4) 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 not being focus 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 27 shows the selected studies.

Table 27. Mobile learning adoption frameworks

STUDY	FRAMEWORK/MODEL
(Mishra & Koehler, 2006)	Technological Pedagogical Content Knowledge (TPACK)
(Motiwalla, 2007)	M-learning framework
(H. 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 et al., 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 et al., 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 et al., 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

Data extract

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 using dynamic tables and graphs.

4.3.3. Results

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 28 shows the details of the journals.

Table 28. 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

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 as those with 13 or more citations. According to this classification, 18 of the 20 studies would fall into this category. Figure 44 shows the number of citations of the studies included in this research, measured during the month of October 2019 according to Google Scholar.

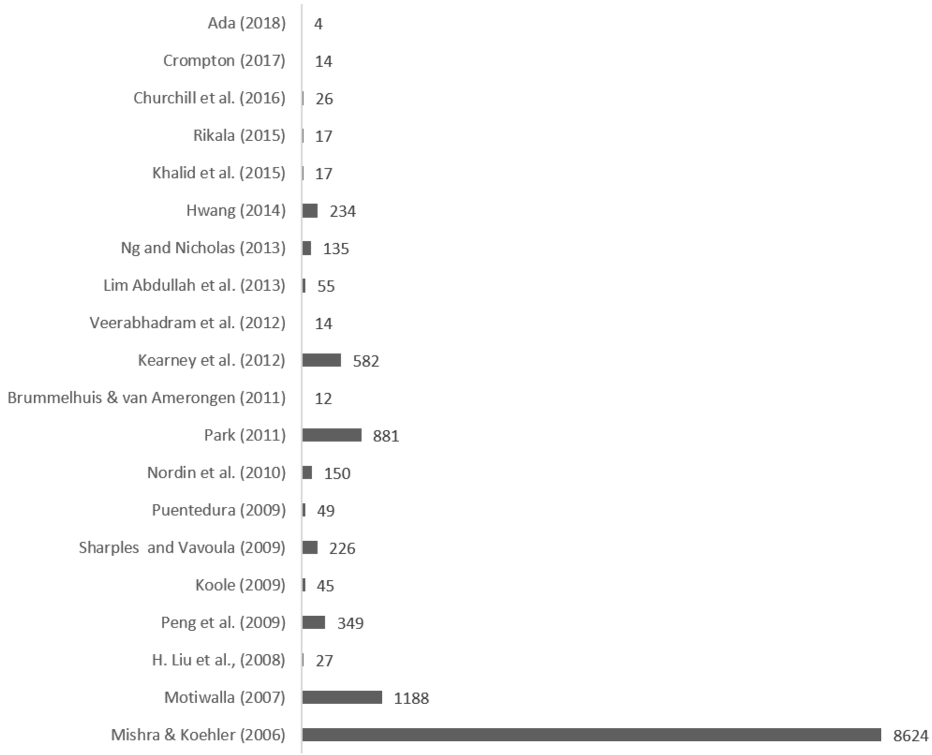


Figure 44. Number of citations per study according to Google Scholar data, October 2019

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 issues and associate conceptually similar issues with each other" (Thomas et. al., 2012, 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 et al., 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 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 29. Table 29 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.

Table 29. 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

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 30.

Table 30. 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)

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 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 31 summarizes the second phase of the synthesis process.

Table 31. Dimensions & subdimensions of the frameworks for mobile adoption

DIMENSION/SUBDIMENSION	PUBLICATIONS
COLLABORATIVE, SOCIAL & 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)
CONTEXTUAL & 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)

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; H. 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 seven design principles for the development of a framework for adoption and sustainable use of mobile learning have been identify and defined: to follow a pedagogical foundation; include the evaluation; implement technology as a means rather than an end and ensure constant technological support; develop physical and virtual learning environments to authenticate and contextualize learning; is permanently develop digital competence; set clear objectives aligned with the mission, vision, and values of the institution; and follow a holistic approach.

Most studies included the technological dimension as a design principle. 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).Figure 45 shows the dimensions. 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).

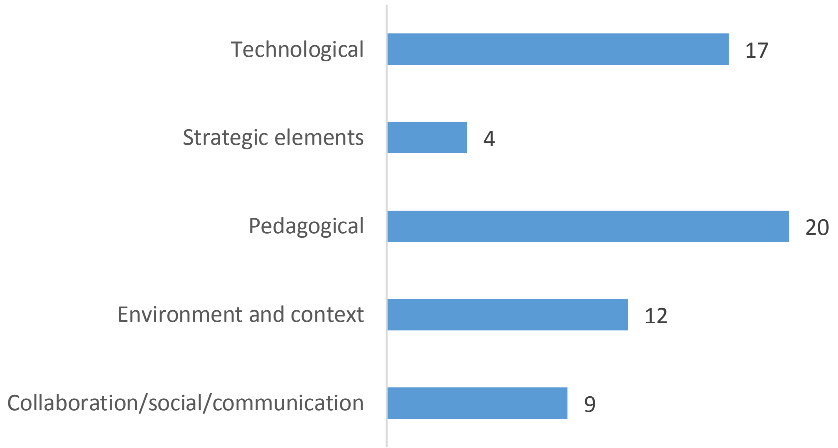
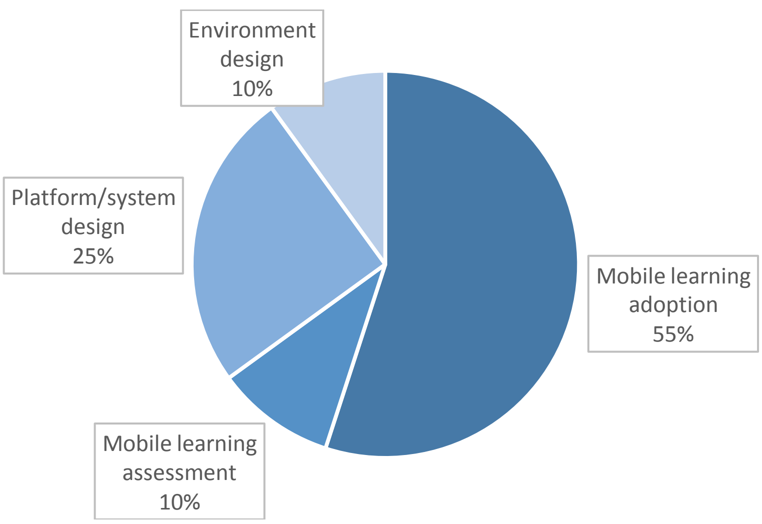


Figure 45. Dimensions of the theoretical frameworks of mobile learning

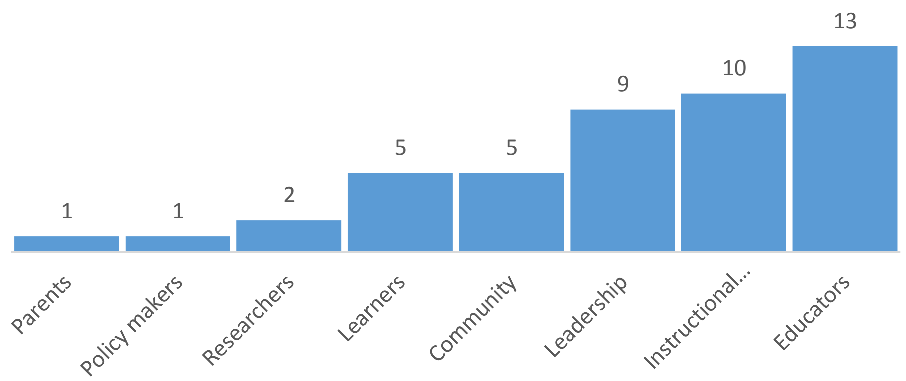
Most of the analysed frameworks focus on the adoption of mobile learning (65%); some specifically focuses on the design of learning activities or environments, and only one specifically focuses on the evaluation design. Figure 46 shows the distribution of the studies



analysed.

Figure 46. Purposes of the theoretical frameworks of mobile learning

Although the most frequent purpose of theoretical frameworks is the adoption of mobile learning, by analysing the target audience to which they are directed, these studies are mainly aimed at educators and designers (Figure 47). 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.

Figure 47. The target audience of the theoretical mobile learning frameworks

4.4. Study 4: "Planning to implement change. Strategic Pillars to Lead Mobile Learning in the Secondary School Environment" [4]

4.4.1. Introduction

This study is based on a systematic broad literature review of Strategic Management and Mobile Learning that included 53 academic publications. Results evidence a lack of research

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[4] Moya, S., & Camacho, M. (2018). Planning to Implement Change: Strategic Pillars to Lead Mobile Learning in the Secondary School Environment. *Conference: International Conference on Open and Innovative EducationAt: Hong Kong*, 205–221. https://bit.ly/2keIkF8

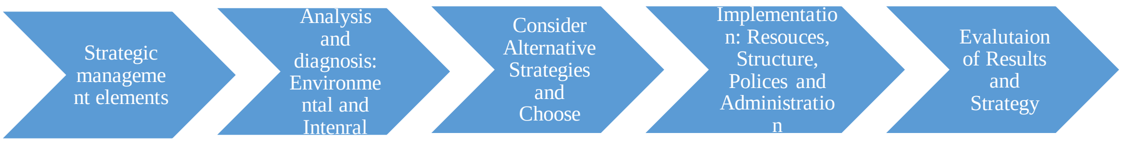
in the field specifically in secondary school contexts. As an output, a prototype conceptual framework for the sustained adoption of Mobile learning has been developed. This framework is upheld by five interrelated key pillars, that orchestrate the research findings. This study focusses on the research question: what are the main characteristics of a strategic management tool to lead Mobile Learning in secondary schools? A thorough analysis has been conducted in the most widely used and recent literature to identify the key pillars upholding the process of strategic management.

Theoretical Background

Strategic management: perspectives and frameworks

There is no universally accepted definition for strategic management. The most common approach concentrates on a strategic process perspective and takes strategic management as a sequence of strategically planned consecutive steps (H Mintzberg & Quinn, 1995; M. Porter & Millar, 1985; Tregore, 1980). There are countless strategic management tools, models, and frameworks, oriented to help firms and managers to develop strategies. The literature is replete with coverage and perspectives on strategic management, substantial issues are essentially the same across authors defining strategic management: establishing organization's mission and setting strategic goals; scan the external and internal environment; evaluate strategic options; develop a plan and allocate resources and monitor results (Andrews, 1965; Tomson; Strickland, 2003; Korey, 1998; Wright, Pringle, Kroll, 1994; Glueck, 1980; Mintzberg, 1995; Porter, 2008; Hines 1991; Drucker 1993; John R. Drew 1997; Boulter 1997; Jack Koteen 1989; Streib and Poister 2002; Bryson 1995).

William F. Glueck developed several frameworks of strategic management based on the general decision-making process. He defined strategic management as a stream of decisions and actions which leads to the development of an effective strategy or strategies to help achieve corporate objectives (Figure 48). The strategic management process as the way in which strategists determine objectives and make strategic decisions (Jauch & Glueck, 1988,



p. 5).

Figure 48. Strategic management framework, Glueck & Juach, 1988 p.5

First phase of the Glueck's model, strategic management elements is considered the core of strategic management or strategic thinking. Management literature often define the core elements as the vision, values, and mission of a firm (Abrahams, 2004; Gurley et al., 2015; Noble, 1990).

Second phase of the Glueck model refers to analyse the context, the most significant management models regarding the scanning the environment phase are SWOT (Strengths, Weakness, Opportunities, Threats); and VUCA (Vulnerability, Uncertainty, Complexity, Ambiguity) (Bennett & Lemoine, 2014).

The third phase of the Glueck model is choice, also called strategy formulation or developing phase, consisting of various alternatives and assure that the appropriate strategy is chosen (Glueck, 1980). The following phase on the Glueck model is the Implementation and covers the challenge to match plans, policies, resources, structure, and administrative style with the strategy. Evaluation is the fifth and last phase of Glueck. Kaplan and Norton developed a specific management framework to evaluate results and strategy: Balance Scorecard (BSC) (Kaplan & Norton, 1996) .For this article, we will refer to the Glueck model for its clarity, precision, and simplicity, incorporating insights from other models.

Definitions and strategies of mobile learning

This section of the article is not included in the thesis as it is a summary of the first chapter.

4.4.2. Methodology

This paper is based on a systematic review of literature relevant to the strategic management and mobile learning in secondary school environments. To ensure that the review process is rigorous and valid, the guidelines suggested by Webster and Watson (2002) and Okoli and Schabram (2010) have been followed. These include: (1) locating the relevant paper published in the leading journals, which has been determined by exploring top journals based on journal impact factor and journal citation reports according to Thomson Reuters scoring updated Marc 2017 and relating strategic planning, mobile learning, education and technology (2) going backward by reviewing citations of the above journals, (3) going

Designing a framework for mobile learning adoption and sustainable development

forward through different online academic research engines such as Google Academic, Yahoo Academic, Bing Academic, Bahidu or Researchgate; research and digging out some major literature database of EBSCOHost; ProQuest ABI, Sciencedirect, JSTOR (4) going backward by reviewing citations of the literature found through the above research procedures; and (5) checking references as suggested by colleagues and experts in the field of research.

Our literature review is concept centric (Webster and Watson 2002), we have used the following selection criteria to choose publications for inclusion in our analysis: reach objectives, relevance, influence, internationally oriented and publication venues.

Based on the above criteria we have selected 53 academic publications for inclusion in our review, including books, thesis, conference papers, reports, and journal articles. 21 publications were in the fields of strategic management and 32 studies in the field of education, of which 10 specifically belong to mobile learning domain. These are depicted in the table 32 below.

Designing a framework for mobile learning adoption and sustainable development

Table 32. Classification of reviewed publications

PUBLICATION TYPE	AUTHOR
Management (21)	Abrhams (2004); Andrews (1971); Bennett & Lemoine (2002); Bennis & Nanus (1985); Chang (2006); Collins & Porras (1994); Daly & Finnigan (2010); Glueck (1980); Gurley et al. (2015); Kaplan & Norton (1996); Leivthwood (2007); Li et al. (2008); Miltenoff, Keengwe & Schnellert (2011); Mintzberg (1994); Mullins (2009); Noble (1990); Porter (1996); Porter (2008); Saloner, Shepard & Podolny (2001); Steiner (1979); Weinbaum & Supovitx (1991).
Mobile learning (10)	Baker-Doyle & Gustavon (2015); Camacho (2016); Chang, Jang & Chen (2015); Cheng, Guan & Chau (2016); Cochrane, Buchem, Camacho, Cronin, Gordon & Keegan (2013); Islam & Grünlund (2016): Lugo, et al. (2016); Rikala (2016); Schmidt et Al (2009); Siu, Chan, Huang & Horn (2014); Toch (2016).
Education (22) (Excluding Mobile learning)	Esteve et al., (2013); Amiel Kubota & Wibes (2016); Bell, (2002); Cambrun & Han (2015); Chai & Siu-Cheung (2016); Daccord & Reich (2015); Datnow & Castellano (2000); Dalziel, et al. (2016); Dobozy, (2017); Flagg-Williams & Rey (2016); Fullan (2015); Hassan & Geys (2016); Hauge, Norenes & Vedoy (2014); Horn (2014); Marleen, et al., (2015); OECD (2016); Penuel et al.,(2012); Peurach & Neumerski (2015); Shirley (2016); Shobel & Scholey (2012); Stein & Coburn (2008); Williams & Larwin (2016).

4.4.3. Results

After having carried out the systematic literature revision, the main research findings show that the strategic concept has evolved in school environments similarly to management context. Strategy has moved from a more functional oriented, excellence in operations concept to a more ongoing broader, creative process. Management tools proved to be effective guiding threads to make strategies work in school contexts. Particularly Glueck's strategic management framework described above, for its simplicity and adaptability is an effective base for organizing strategic management to lead mobile learning and has been used to illustrate mobile learning strategy framework. Figure 49 shows the customization of Glueck's framework for Mobile learning adoption.

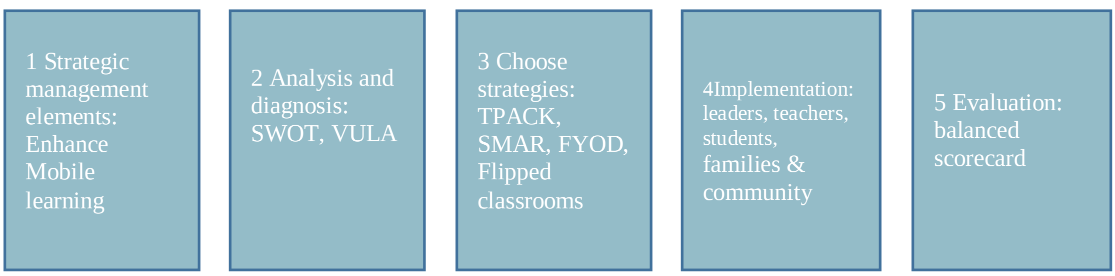


Figure 49. Glueck (1988) strategic management process framework adapted for mobile learning

To provide further details about the framework a strategy house tool has been designed. Starting for the first phase of the model, strategic elements, we found significant level of consensus in strategic thinking, as where and how to be positioned in terms of integration of mobile Learning. Acknowledgments on the contribution to the goal of enhancing learning and specific goals of contributing to the 21st century skillsets and leverage of the school organization and performance. We define enhance mobile learning as the core goal of the framework.

Values are the foundation of firm's strategy, the essence of their organization or its core ideology, which is comprised of the organization's key values and purpose. Regarding the vast management literature providing prove on values such as collaboration, communication, courage, creativity, distributed leadership and sharing (Hargreaves & Fullan, 2012; Horn, 2014; Penuel et al., 2011). We highlighted four crucial values for developing an effective mobile learning framework: creativity, courage, communication, and collaboration (Figure 50).

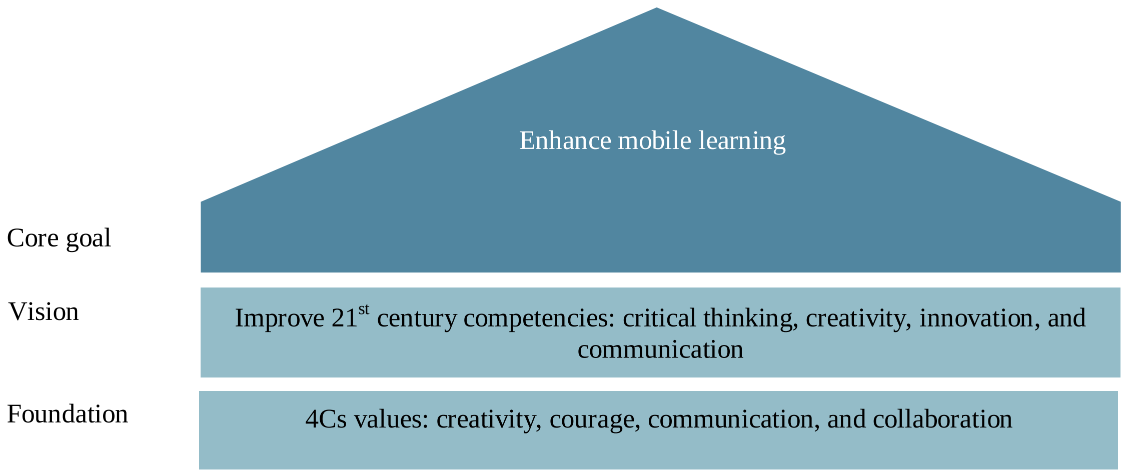


Figure 50. Mobile learning strategic management framework: first phase

Moving to the second Glueck's model phase, blueprint complex strategies such as mobile learning can't use static linear frameworks, a holistic perspective is needed, that demands managing VUCA environments, towards minimizing uncertainty, simplify complexity, clarify ambiguity minimizing confusion with a clear framework and optimize volatility prediction (Weinbaum & Supovitz, 1991). SWOT analysis is a widely use framework in schools and will be essential in further investigations to identify the factors enhancing and challenging the framework. For this framework, environmental factors have to be constantly analysed and considered as part of an on-going process of approximation and reformation of mobile learning strategy (Guohui & Eppler, 2008) as shown in Figure 51.

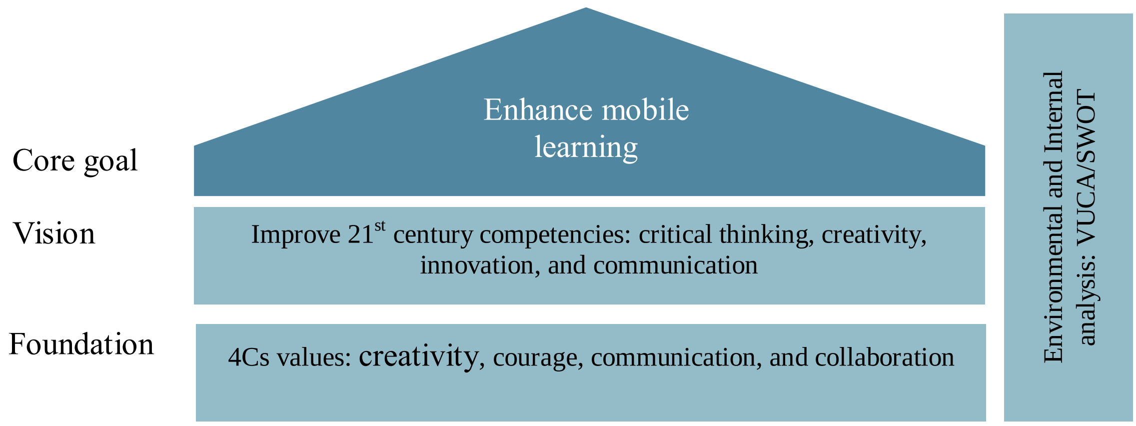


Figure 51.Mobile learning strategic management framework: second phase

The third phase of Glueck's model: strategy choice, or formulation, we found that literature has significantly proven success on specific formulated mobile learning strategies such as Learning Design, TPACK, resources' affordability and availability such as BYOD or space management such as flipped classrooms. Attending proved efficiency in those fundamental mobile learning strategies, we found that they complement each other, are interconnected, and feedback the mobile learning process. Therefore, in this third phase of Glueck's model is not just about choosing among different strategies but how to harmonically combine them to maximize and optimize the mobile learning framework (Figure 52).

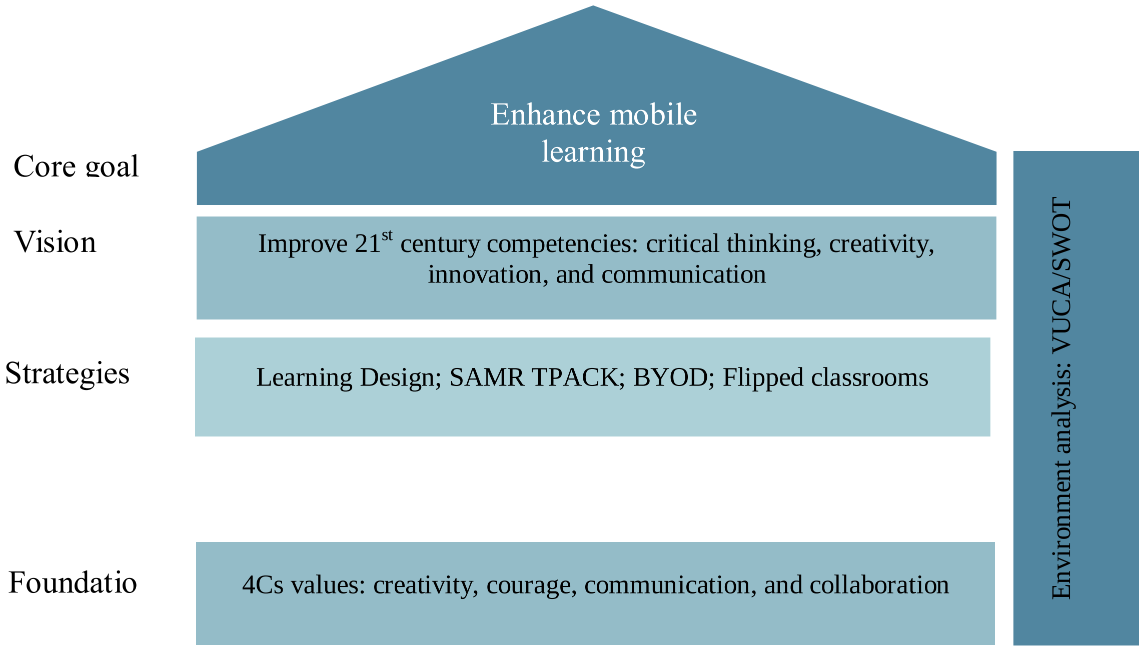


Figure 52. Mobile learning Strategic management framework: third phase

The next phase of Glueck's model is implementation. On the main resource's management in the implementation phase: technology and human capital (Kaplan & Norton, 1996),we found evidence that technology does not itself lead to a positive effect (Miltenoff et al., 2013). We will consider people as the essential ingredient of the framework. We found that the key pillars, not only of the implementation phase, but the hole framework are leaders, teachers, students, family, and community. For the propose of presenting the framework we will consider them independently, though they are constantly interacting with each other. Those five pillars have multiple proven mobile learning benefits and positives impacts. On the table 33 below, mobile learning's positive and negative impacts have been adapted to each of the pillars of this model based on Islam and Grünlund research (Islam & Grünlund, 2016).

Designing a framework for mobile learning adoption and sustainable development

Table 33. Adaptation Islam and Grünlund (2016) based on Fisher, Holomb and Penuel publications

KEY PILLAR	MOBILE LEARNING IMPACT
Leaders	Access to in class content Improve multilevel communication Standardization to ensure quality levels Team management motivation Online Feedback
Teachers	Classroom dynamism Collaboration Computing skills Constructivist and flexible teaching Discipline behaviour problems Teacher-student interaction improve Professional development Overdependency on information (negative)
Students	Cognitive skills Computing skills Engagement and motivation Help special needs students Homework Quality of work and achievements Research and writing skills Self-direct, independent learning Insignificant academic achievement (Negative) Physiological as well as physical strains (Negative) Additional Distraction (Negative)
Family	Increases parental involvement in school and technology Literacy Assist Homework
Community	Industry: Increases innovations and sales; reduce prices. Reduce socio-educational inequalities

Defining the core roles, activities and responsibilities is key for this framework phase keeping in mind that all pillars are interconnected and constantly interrelated any role, responsibility or activity of each pillar' framework must be aligned and oriented to achieve the strategic goals.

The role of school leaders must be oriented to guide the school, to constantly focus and redirect the school towards the strategic objectives aligning resources. Design, enact and coordinate infrastructure components and continuously improve in response to new understandings garnered through use and to changing understandings, resources, and expectations.

The main role of teachers is to facilitate and develop teaching cycle (design and plan, engage with students, reflection, and professional development) (Dalziel et al., 2016).

Teacher's role switch from class leader to a facilitator role (Fairman 2004; Islam & Grünlund, 2016). At the same time teachers are require leadership roles (Darling et al., 1995; Fullan 1996, Leberman and Miller 1996, Spillane, and Healey 2010). Distributed leadership, among teachers and all framework stakeholders enhance goal results. Sharing empowerment structures for teachers in terms of power, resources, opportunities, support, and information (Freire & Fernandes, 2015; Runhaar & Sanders, 2015).

Student's role switches to the centre of the learning process (Toch, 2016), students must broad their responsibilities oriented to a proactively contribution in the mobile learning process. The role of families in this framework, must be actively contributing to strategies, such as BYOD, or flipping classrooms, as well as support and feedback all segments of the framework. The community pillar is not only limited to educational institutions but also to a wide range of organizations, such as technological companies. The contribution to the framework is wide contributing to create technologies & methodologies and learning environment of the framework, as well as providing and developing tools and resources (Figure 53).

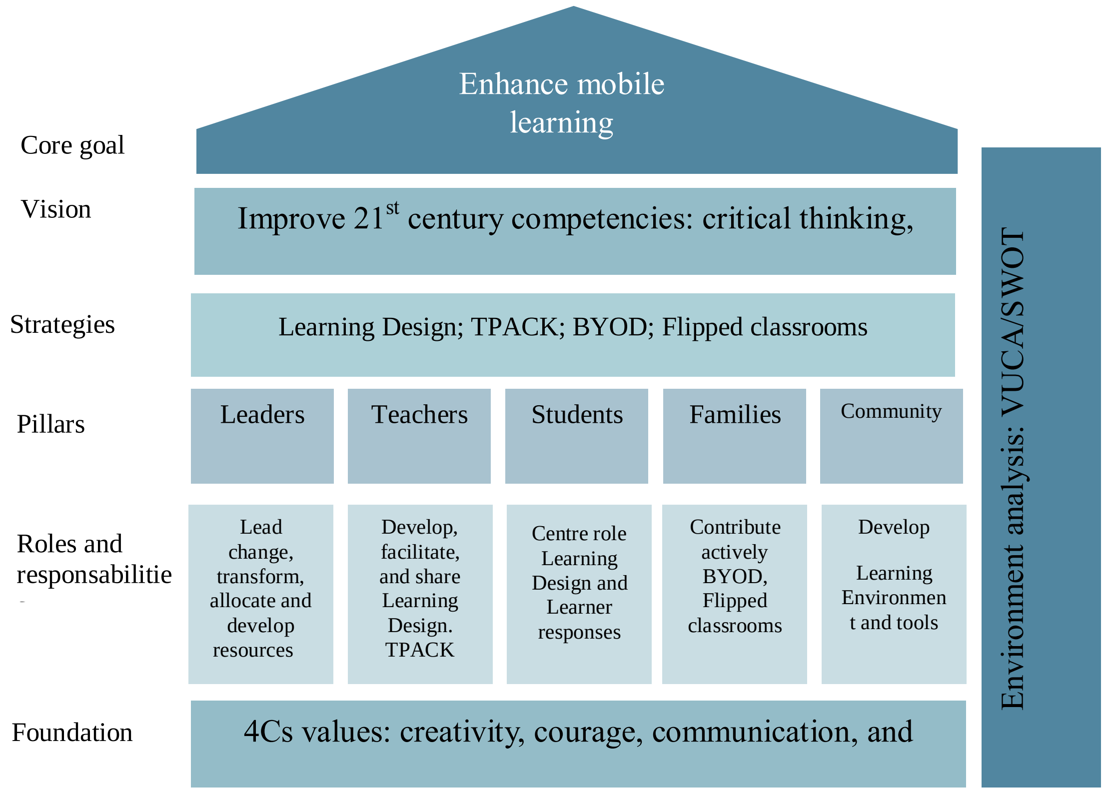


Figure 53.Mobile learning strategic management framework: fourth phase

Fifth and last phase of Glueck's model is evaluation. Literature provide numerous examples demonstrating the applicability of BSC (Balance Scorecard) in educational environments. (Sholbel & Scholey, 2012). The evaluation of the process at any stage, provides feedback in the framework to constantly readjust the ongoing process of focusing on the strategic goals. Historically Balanced scorecards in Education were focused on performance metrics associated with learning, literature in recent years has introduced other relevant performance indicators evaluating multiple strategic objectives and resources (Sholbel & Scholey, 2012) (Figure 54).

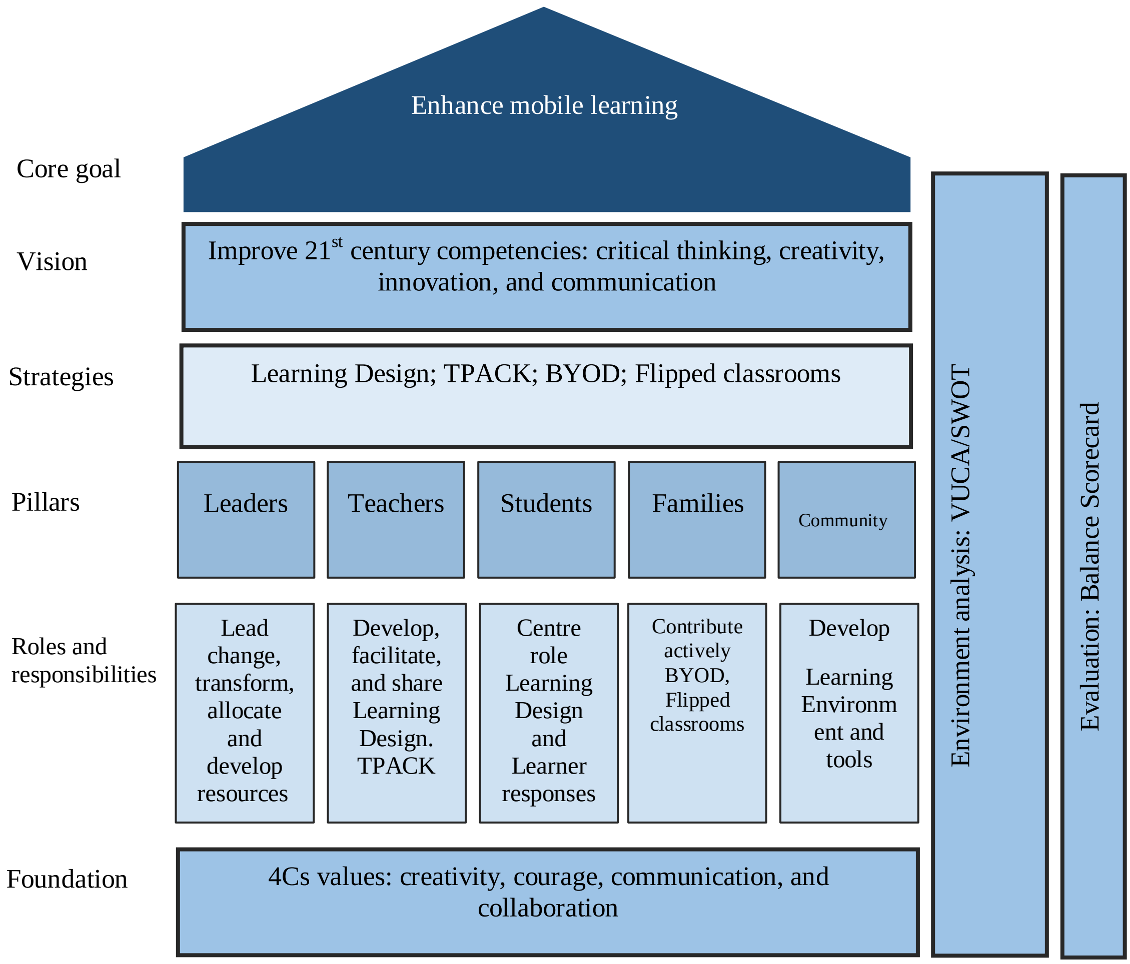


Figure 54.Mobile learning strategic management framework, fifth phase first prototype

CHAPER 5

DESIGN CYCLE THREE: INTERACTIVE CYCLES OF TESTING AND REFINING THE INITIAL MOBILE LEARNING FRAMEWORK

In this Chapter, the third phase of the educational design-based research is developed. This phase consists of three iterative cycles with the objective of testing, evaluating and refining in a practical way the prototype presented in the previous phase (Reeves et al., 2005). Iterations are a fundamental part of the DBR process since they refine and model the initial design, multiple iterations guarantee a more precise fit of the initial prototype (Stemberg & Cencic, 2014). In this part, the initial mobile learning framework is evaluated through three iterations. In this phase, the fourth and fifth research question are answered: RQ4. What are the critical success factors for the adoption and sustainable use of mobile learning in education? and RQ5. What are the indicators and characteristics to develop a tool to evaluate and monitor the adoption of mobile learning?

Three iterations collected in four publications have been developed in this design cycle. The first iteration of this phase consists of research based on an expert judgement conducted in Catalonia with the objective of identifying and prioritizing the critical success factors for the adoption and sustainable use of mobile learning. Study 5: "Identifying the key success factors for the adoption of mobile learning", it consists of a mmixed quantiative and qualitative investigation consisting of an expert trial, where 7 experts participated.

The second iteration aims to identify and order the factors that affect the adoption of mobile learning in Catalonia and the results have been published in two studies: study 6: " What factors matter most for mobile learning adoption?" is based on a review of the literature to identify and code the factors that affect the adoption of the literature, and study 7: "factores que afectan la adopción de mobile learning en Cataluña", based on a questionnaire to 147 teachers in Catalonia.

The third iteration reflects the indicators to evaluate and adjust a theoretical framework for the adoption of mobile learning, responding to the fifth research question and whose results are published in study 8: “Dashboard for monitoring the adoption of mobile learning in education”.

5.1. Study 5:” Identifying the key success factors for the adoption of mobile learning” [5]

5.1.1. Introduction

This study investigates the factors affecting mobile learning adoption and the sustainable use of mobile learning in Catalonia. The research in this study was designed according to a mixed methods paradigm applying a mixed research approach weighted toward quantitative data, including a literature review, a systematic review, and an expert judgement. A total of 361 factors were identified by reviewing 74 studies; twenty-six studies were included in the systematic review; and seven Catalan experts participated in the expert trial, including three school leaders, two university experts and two education inspectors. The findings reveal that the factors that affect mobile learning can be grouped into five categories arranged from highest to lowest impact as follows: leadership, personal character and ethics, pedagogical, digital literacy, and technological resources. The findings are expected to be useful both in academia and for school stakeholders as insights for further research and successful mobile learning improvements.

The objective of this study is to identify and evaluate the critical factors that shape the adoption and sustainable use of mobile learning conducting a case study. This study considers the adoption of mobile learning as a strategic process of change and therefore includes studies in the field of strategic management. The three specific research questions driving this study are as follows:

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[5] Moya, S., & Camacho, M. Managing the key success factors for the adoption of mobile learning. *Journal of technology, knowledge and learning*. Under review.

RQ1. What are the critical success factors for the adoption and sustainable use of mobile learning in education, as identified in the main academic publications between 2008 and 2018?

RQ2. How can the key factors affecting mobile learning be grouped in a hierarchical taxonomy in the education context?

RQ3. What categories of success factors are given more importance?

5.1.2. Methodology

This research is developed under an interpretive paradigm in which reality is complex. The different methodologies included in the study combine qualitative and quantitative data to provide a broad interpretation aimed at answering the research questions. The generalization of the results is linked to the context of the study (Guba & Lincoln, 1981).

Explanatory sequential design (Creswell, 2012) was used to direct different methods and mixed collection data tools to triangulate and validate the research and prove evidence. Table 34 illustrates the research design.

Table 34. Research Design

RESEARCH OBJECTIVES	RESEARCH QUESTION	DATA COLLECTION METHOD & INSTRUMENT	SAMPLE/ PARTICIPANTS
Develop an initial understanding of key factors affecting mobile learning adoption. What are the key success factors in integrating mobile learning within education?	RQ1	Literature review	n= 74 studies. n= 361 Factors
To collect evidence regarding common barriers and enablers of mobile learning. Identify main categories grouping factors affecting mobile learning adoption. Gather information needed to design the expert judgment research model	RQ2	Systematic review	n= 26 studies
To collect evidence regarding the importance of the most common barriers and enablers of mobile learning in Catalonia. To explain and validate the findings from previous research	RQ3.	Expert Judgement	n= 7 experts

The literature review was based on a concept-centric approach (Okoli & Schabram, 2010; Webster & Watson, 2002). Based on the extended consideration of mobile learning adoption as a strategic process, as described in the theoretical framework of this study, both the mobile learning and strategic management critical factors were included in this research. The results were filtered by timespan between 2008 and 2018, resulting in 203 studies. A total of 74 studies were selected based on titles and the reading of their abstracts.

For the systematic review, the protocol proposed by Okoli & Schabram (2010) has been followed. This guide is aimed at structuring and organizing the systematic review of literature through the process consisting of four phases: (1) planning, (2) selection based on inclusion criteria, (3) data extraction, and (4) analysis. The first step requires to identify the purpose of the research, the main purpose of this study is to identify and evaluate the critical factors that shape the adoption and sustainable use of mobile learning. Second phase focuses on the review of the literature and practical screen that have been addressed in the previous section. The inclusion and exclusion criteria necessary to execute the third phase are detailed below.

Inclusion criteria: mobile learning or M-learning integration or adoption were among the key variables of the study, categorization or grouping was among the key variables, and studies must have been published between 2008 and 2018. A total of 35 full texts were identified as eligible for the review and were comprehensively analyzed by both authors. Exclusion criteria determine the quality appraisal: studies are based on academically relevant methodologies; provide research in real learning contexts; and published in prestigious journals in the field of mobile learning. Finally, 26 studies were included in the systematic review. Figure 55 shows the data search and collection process.

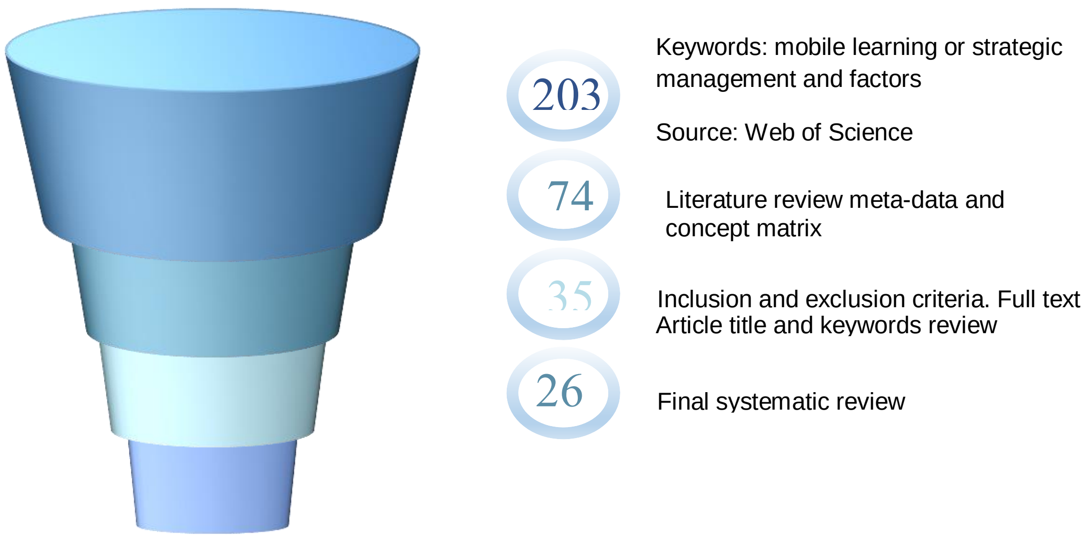


Figure 55. Diagram of the systematic review search process

The fourth phase of the systematic review protocol proposed by Okoli and Schabram (2010) consists of data extraction. The main information that has been extracted from the studies analyzed are the factors that affect the adoption of mobile learning and its categories. This information together with the metadata of the studies has been synthesized and structured in a metadata table.

Appendix 1 there is the link to access the metadata table. Figure 56 shows the distribution of publications; the average publication year of the 26 studies is 2013. Although many recent studies conclude that Asia leads in scientific publications on mobile learning (Crompton et al., 2019), Europe is the leading region among the studies included in the systematic review, as shown in Figure 57. Table 35 shows the data collection methods, theories and sample size of the publications included in this research. The most common data collection method is the questionnaire – 12 out of the 26 studies used questionnaires. The most used theory is the TAM (Davis, 1989).

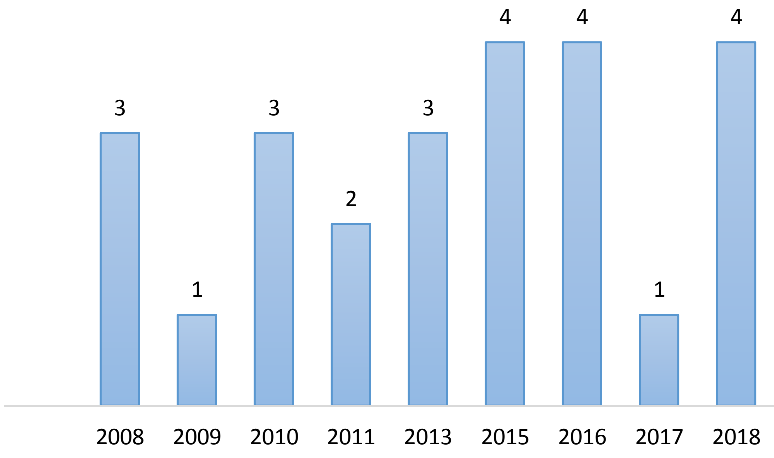


Figure 56. Distribution of publications years of studies included in this research

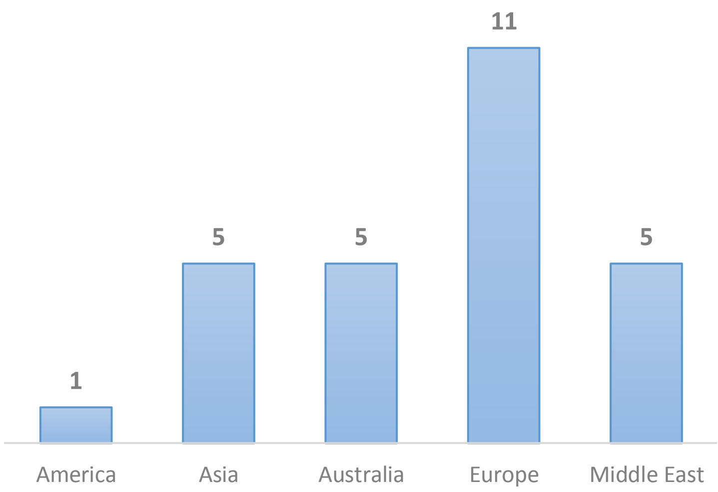


Figure 57. Geographical distribution by the number of articles

Table 35. Data collection methods, theories and sample size used in this research

STUDY	THEORY	METHODOLOGY/DATA COLLECTION	SAMPLE
(Aguti et al., 2014)		Survey experts	16 experts
(Alrasheedi & Capretz, 2015)		Meta-analysis	19 studies
(Al-Sharhan et al., 2010)		Literature review	
(Bower et al., 2015)		Case study	
(Cochrane & Bateman, 2010)		Analysis of previous studies/reports	
(Ekberg & Gao, 2018)		Semi structured interviews	
(Gao et al., 2011)	TAM	Review and survey pilot test	25 students
(Goyal et al., 2010)		Questionnaire	401 Students 57 and Teachers
(Hamidi & Chavoshi, 2018)	TAM	Questionnaire	300 Students
(Hao et al., 2017)	TAM	Questionnaire	292 Students
(Kukulska-Hulme, 2008)		Literature review	
(Y. Liu et al., 2009)	TAM	Questionnaire	209 Students
(López-Hernández & Silva-Pérez, 2016)	UTAUT	Questionnaire	411 Students
(Lu & Viehland, 2008)	TAM	Questionnaire	180 Students
(Mahdi, 2018)		Meta-analysis	16 Studies
(Mercader, 2018)		Questionnaire	164 Teachers
(Rikala, 2015)		Thesis	
(Sabah, 2016)	TAM	Questionnaire	80 Students
(Sarrab et al., 2016)	TAM	Questionnaire	806 Students
(Spector, 2013)		Analysis of previous studies/reports	
(Stacey & Gerbic, 2008)		Literature review	
(Tay et al., 2013)		Questionnaire	Teachers, students, and parents
(Teoh, 2011)		Analysis of previous studies/reports	5 Studies
UNESCO (2011)		Report	
(Yadegaridehkordi et al., 2013)	TAM	Questionnaire	350 Students
(Yeap et al., 2016)	TAM	Questionnaire	900 Students

Expert judgment

Expert judgement was used to answer the third research question. The research was conducted in the context of Catalonian secondary schools in spring 2018. According to

Generalitat de Catalunya, Xarxa Telemàtica Educativa de Catalunya, in 2017, Catalonia had 1,146 secondary schools. The Catalan education system enrolls approximately 500,000 students and employs 45,000 teachers.

The expert judgement process mainly focused on discussing uncertainty and understanding impacts across fields (Ashcroft et al., 2016). The three different fields represented were scientific, schools, and government, as represented by academic experts, school leaders and inspectors. Expert judgment took place in Universitat Rovira I Virgili in Spain. Participants in the expert judgment were selected from different backgrounds in education to better understand the context in which the data were collected. A total of seven experts participated in the expert judgement. Three participants were school leaders, two were educational inspectors, and two were university experts. Participants included two males and five females. The transcript was developed from digital recordings. Appendix 2 summarizes the Expert Judgement protocol.

5.1.3. Results

Factors affecting mobile learning

The literature highlights isolated recurrent factors affecting strategic management and mobile learning. Most of the studies analyzed were focused on the perceived performance or learning outcomes. A significant number of the studies analyzed were focused on students' or teachers' perceptions. Based on the literature review of 74 studies, 361 different factors have been identified.

The most cited factor is communication, which was cited in 10 studies; followed by leadership, highlighted in 6 studies; and assimilation with curriculum and institutional support were cited in five and four studies, respectively.

Factors affecting mobile learning

There has been considerable debate about the use of performance management tools in education, the literature shows that there are more examples demonstrating their value than there are detractors (Hernández-Ramos, 2014; Ng & Nicholas, 2013; Nikolopoulou & Gialamas, 2016). To identify the categories that affect the adoption of mobile learning, this study takes as a reference the categorization of factors that affect strategic management.

There is significant consistency among the grouping of the factors affecting strategic management in two big categories. On the one hand are hard factors, including those impacting company performances in a way that companies can reasonably handle, manage, and measure. This category includes factors such as technological resources, a company's structure, managerial skills, strategy, and organization.

On the other hand, there are soft factors. This category includes the factors affecting the company's soul, culture, and organizational behaviour in three main areas: individual, group and organization. Table 36 summarizes the different studies that have identified categories of factors affecting strategic management. The most cited factor is communication, which was cited in 10 studies; followed by leadership, highlighted in 6 studies; and assimilation with curriculum and institutional support were cited in five and four studies, respectively.

Table 36. Categories of factors affecting strategic management process: frameworks and studies

CATEGORY	STUDY WORKING	FRAMEWORK	STUDY
Hard	Hard	7 S framework	(Peters & Waterman, 2006)
	Hard	8 S framework	(Higgins, 2005)
	Performance	5 As framework	(Dewar et al., 2011)
	Independent	Knowledge Project Management Performance Assessment	(Humaidi et al., 2010)
	Hard	A framework of strategy implementation research	(Guohui & Eppler, 2008)
Soft	Soft	7 S framework	(Peters & Waterman, 2006)
	Soft	A framework of strategy implementation research	(Guohui & Eppler, 2008)
	Soft	8 S framework	(Higgins, 2005)
	Health	5 As framework	(Dewar et al., 2011)
	Dependent	Knowledge Project Management Performance Assessment	(Humaidi et al., 2010)

In the field of mobile learning, A. Khan, Al-Shihi, Al-Khanjari and Sarrab (2015) conducted a study reviewing the programs for the adoption of mobile learning in six countries and highlighted two constrains for mobile learning adoption: the technical and non-technical consists.

Together with the categorization of factors that affect strategic management, to identify the categories that affect mobile learning, this study is based on the variables used in the

TAM theory of the academic documents included in the systematic review.

As anticipated in the theoretical framework, Table 37 indicates that TAM (Davis, 1989) is the most used theory. Nine studies included in the systematic review applied the TAM approach. Figure 58 shows the TAM diagram.

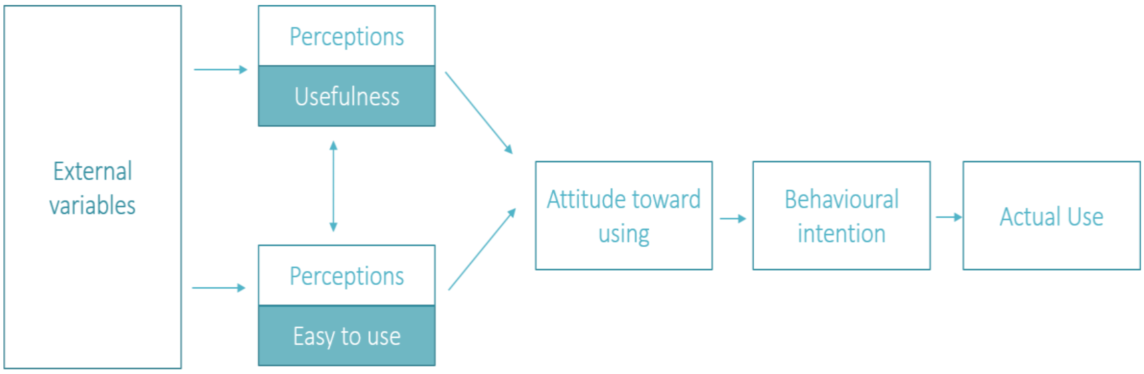


Figure 58. Original variables in TAM and their relationship (Davis 1989)

All nine of the studies analyzed adopted the original TAM theory specifying the external variables or the additional relationships between factors. Tabled 37 shows the different adoptions made by the studies analyzed in this systematic review.

Table 37. TAM adoptions included in this research

TAM DIAGRAM AREA	FACTORS	STUDY
External variables	Context	(Gao et al., 2011)
	Context factor	(Hamidi & Chavoshi, 2018)
	Control variables	(Sabah, 2016)
	Economic	(Sarrab et al., 2016)
	Enjoyment	(Sarrab et al., 2016)
	Image	(Hao et al., 2017)
	Moderator variables	(Sabah, 2016)
	Perceived financial resources	(Lu & Viehland, 2008)
	Perceived mobility value	(Yadegaridehkordi et al., 2013)
	Prior use of e-learning	(Yadegaridehkordi et al., 2013)
	Prior use of electronic learning	(Lu & Viehland, 2008)
	Self-efficacy	(Lu & Viehland, 2008)
	Social	(Sarrab et al., 2016)
	Subjective norm	(Hao et al., 2017); (Lu & Viehland, 2008)
	Suitable	(Sarrab et al., 2016)
	Voluntariness	(Hao et al., 2017)
Perceived	Ease of use	(Hao et al., 2017; Y. Liu et al., 2009; Lu & Viehland,

		2008; Sabah, 2016; Sarrab et al., 2016; Yadegaridehkordi et al., 2013; Yeap et al., 2016)
	Innovativeness	(Hao et al., 2017)
	Instructor Readiness	(Yeap et al., 2016)
	Learning Autonomy	(Yeap et al., 2016)
	Long term usefulness	(Y. Liu et al., 2009)
	M-learning services (awareness of services)	(Sabah, 2016)
	Mobile limitations	(Sabah, 2016)
	Neat-term usefulness	(Y. Liu et al., 2009)
	Option leader	(Yeap et al., 2016)
	Perceived facilitation	(Hao et al., 2017)
	Perceived Self Efficacy	(Yeap et al., 2016)
	Personal characters and features	(Hamidi & Chavoshi, 2018)
	Personal Initiatives and Characteristics	(Gao et al., 2011)
	Personal innovativeness	(Y. Liu et al., 2009)
	Self-efficacy	(Yadegaridehkordi et al., 2013)
	Social influential	(Sabah, 2016)
	Student Readiness	(Yeap et al., 2016)
	Subjective norm	(Yeap et al., 2016)
	Trust factor	(Hamidi & Chavoshi, 2018)
	Trust The user’s beliefs	(Gao et al., 2011)
	Usefulness	(Hamidi & Chavoshi, 2018; Hao et al., 2017; Lu & Viehland, 2008; Sabah, 2016; Sarrab et al., 2016; Yeap et al., 2016)

From the analysis of the rest of the 17 studies included in this systematic review, we can identify five categories that have been recurrently used to categorize the factors.

Technological resources: the first category is related to technological resources and includes factors such as technological infrastructure, navigation, internet connection, mobile tools, level of integration, technical support, student-device ratio, or hardware. The most common ways to refer to this category are: Affordability (UNESCO, 2011); Appropriate choice of mobile devices (Cochrane and Bateman, 2010); Device (Kukulska-Hulme, 2008); Information and Communication Technology (ICT) infrastructure (Rikala, 2015); Infrastructure component (Al-Sharhan et al., 2010); Mobile limitations (Sabah, 2016);Physical and technological infrastructures (Tay et al., 2013); Quality e-learning systems (Aguti et al., 2014); Smart Classroom (Al-Sharhan et al., 2010); Smart School (Al-Sharhan et al., 2010); Technological (Goyal et al. 2010); Technological aspects (Bower et al., 2015); Technological factors (Mahdi, 2018; Teoh, 2011); and Technology (Alrasheedi and Capretz, 2015).

Pedagogical factors: the second category encompasses pedagogical factors, such as classroom integration, adaptability of the course, assessment, availability of content and software, critical thinking, thinking development, time management, recognition of informal learning, defining target learner groups for m-Learning, teaching preparation, design approach, gamification, virtual environments and customization. It is the most cited category among the studies analyzed. The following concepts are included in this category: Curriculum (Rikala, 2015); Curriculum and assessment (Tay et al., 2013); Defined target learning groups (UNESCO, 2011); E-content component (Al-Sharhan et al., 2010); E-learning course delivery strategies (Aguti et al., 2014); Learning gateway component (Al-Sharhan et al., 2010); Learning related (Mahdi, 2018); Lecture modelling the pedagogical use of the tools (Cochrane and Bateman, 2010); Level of Pedagogical integration (Cochrane and Bateman, 2010); Pedagogic considerations (Stacey and Gerbic, 2008); Pedagogical (Goyal et al., 2010); Pedagogical aspects (Bower et al., 2015); Recognition of informal learning (UNESCO, 2011); Teaching Pedagogy (Alrasheedi and Capretz, 2015; Teoh 2011); Teaching preparation (Ekberg and Gao, 2018).

Digital literacy: a third category refers to the educational community's mobile learning skills or digital literacy. To this category belong the following factors: teachers' digital knowledge, training, students' knowledge, teachers' and students' digital competency, and teachers' practices and digital assessment knowledge. Esteve (2015, p. 185) defined digital literacy as the attitude and the ability of individuals to specifically use the tools to identify, access, manage, evaluate, analyse and synthesize digital resources, build new knowledge, communicate and create new expressions. Several studies identify training as a key category of factors that affect the adoption of mobile learning: Creation of learning community (Cochrane and Bateman, 2010); ICT training (Ekberg & Gao, 2018); Instructor Readiness (Yeap et al. 2016); Learning Approach (Teoh, 2011); Learning approach (Alrasheedi & Capretz, 2015); Moderator variables (Sabah, 2016); Prior use of e-learning (Yadegaridehkordi et al., 2013); Prior use of electronic learning (Lu & Viehland, 2008); Professional barriers (Mercader, 2018); Professional development (Rikala, 2015); Professional development (Tay et al., 2013); Regarding teachers professional development (Stacey & Gerbic, 2008); Student Readiness (Yeap et al., 2016); Teacher (Goyal et al., 2010); Training component (Al-Sharhan et al., 2010).

Personal characteristics, features, and ethics: the fourth category integrates human-related factors, with a focus on individual personal character and ethics. Often labelled as soft or human factors, this category includes behaviours and attitudes, teachers' attitudes, motivation, resistance to change and computer ethics. There is a vast body of literature in the field of computer ethics; the standard approach to computer ethics is to evaluate morally problematic uses of ICT through the lens of different ethical theories and moral philosophies (S. Jones, 2017). This category also includes demographic factors. In their study of mobile learning adoption, Tan et al., (2012) evidenced the influence on the adoption of mobile learning of demographic factors such as gender, age, and experience. The factors related to ICT anxiety have been repeatedly reported as a significant importance in the adoption of mobile learning (Mac Callum et al., 2014). Some authors highlighted the importance of understanding cultural limits and the social environment to contextualize this category (Keengwe & Bhargava, 2014). Some of the authors analyzed refer to this category using the following expressions: Personal characters, features and ethics; Attitude and knowledge (Ekberg & Gao, 2018); Enjoyment (Sarrab et al., 2016); Human use and adoption (Spector 2013); Image (Hao et al., 2017); Individual, social and psychological ; Innovativeness (Hao et al. 2017); Learning Autonomy (Yeap et al., 2016); Perceived financial resources (Lu & Viehland, 2008); Perceived Self Efficacy (Yeap et al., 2016); Personal barriers (Mercader, 2018); Personal characters and features (Hamidi & Chavoshi 2018); Personal Initiatives and Characteristics (Gao et al., 2011); Personal innovativeness (Y. Liu et al., 2009); Subjective norm (Yeap et al., 2016); Techer's beliefs and practices (Rikala, 2015);Trust factor (Hamidi & Chavoshi, 2018); Trust The user's beliefs (Gao et al., 2011); User (motivations, demographics, emotions...) (Kukulska-Hulme, 2008); Voluntariness (Hao et al., 2017).

Leadership: the fifth category integrates human-related factors, with affecting organizations and groups and highlighting leadership among the most cited. The most cited factor included in this category is communication, collaboration, and cooperation. The following nomenclatures have been included in this category: Leadership; Context (Gao et al., 2011); Context factor (Hamidi & Chavoshi, 2018); Contextual barriers (Mercader ,2018); Facilitating condition (Hao et al., 2017); Institutional (Goyal et al., 2010); Institutional barriers (Mercader 2018); Institutional success factors (Stacey & Gerbic, 2008); Leadership (UNESCO, 2011); Locations (Kukulska-Hulme 2008); Management support (Alrasheedi &

Capretz, 2015; Teoh, 2011); Media and Awareness Campaign (Al-Sharhan et al. 2010); Network (continuity, linkage across contexts...) (Kukulska-Hulme 2008); Option leader (Yeap et al., 2016); Policy and school leadership (Tay et al.,, 2013); School leadership (Rikala 2015); Social (Sarrab et al., 2016); social influential (López-Hernández & Silva-Pérez,, 2016; Sabah 2016); Subjective norm (Hao et al., 2017); Subjective norm (Lu & Viehland, 2008); Support from educators and parents (UNESCO, 2011); Support from school and leadership (Ekberg & Gao, 2018); Technological and pedagogical support (Cochrane & Bateman, 2010); Well-defined goals (UNESCO, 2011).

Based on the above analysis, the five categories identified were used to recategorize the 112 categories identified in the 26 studies included in the systematic review. Some categories fit in more than one group. The classification was reviewed by both authors. Differences in their interpretations were resolved upon discussion.

The two groups identified in the critical success factors affecting strategic were used to position the five categories. Table 38 and Figure 59 show the dimensions and categories of factors affecting mobile learning adoption and the number of mentions in the 26 studies included in the systematic review.

Table 38. Dimension and categories of factors affecting mobile learning adoption

DIMENSION	CATEGORY	RECURRENCE IN THE SYSTEMATIC REVIEW
Hard		58
	Technological resources	18
	Pedagogical	23
	Digital literacy	17
Soft		54
	Personal characteristics features and ethics	24
	Leadership	30
	Total	112

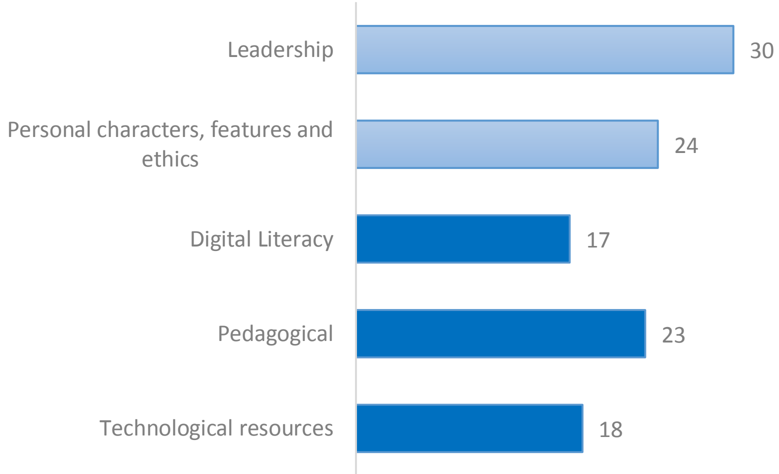


Figure 59. Categorization of factors affecting mobile learning against citations

The TAM model has been extending, grouping, and specifying external contextual factors based on the categories identified above. Relationships with the main TAM components are also proposed. Figure 60 illustrates the research model.

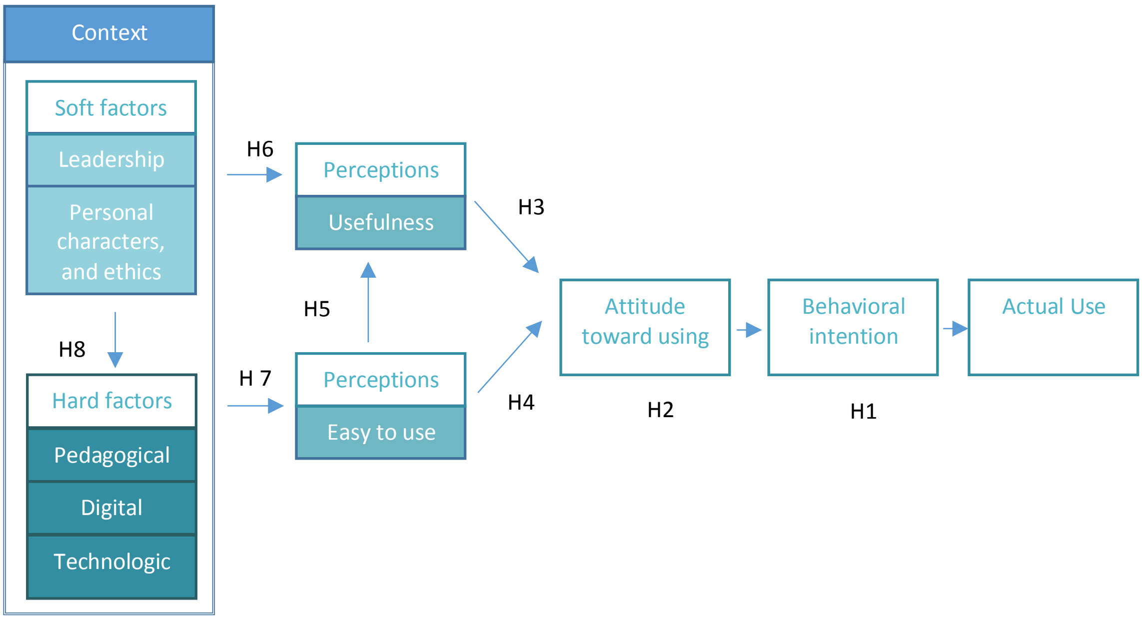


Figure 60. The research mobile adoption, adapted from the technology acceptance model (Davis, 1989)

Of the nine studies included in the systematic review that used the TAM model, only one reveals nonpositive results in one of the hypotheses analyzed: H3 (Hamidi & Chavoshi, 2018). Table 39 shows the results of the hypotheses used in the studies, the size of the samples and the country of origin of the main author.

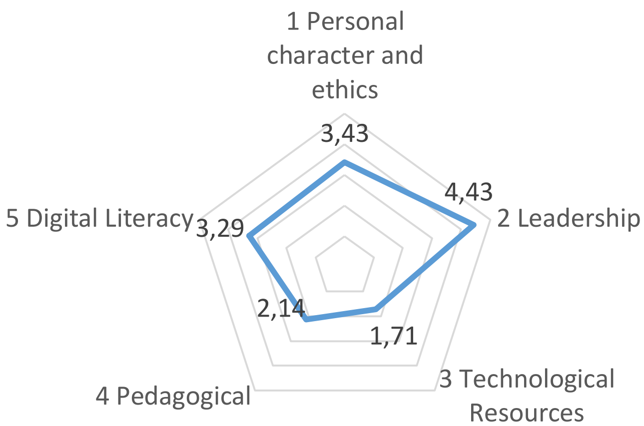
Table 39. Results of hypotheses about factors that affect mobile learning

HYPOTHESIS	STUDY	RESULT	SAMPLE SIZE	COUNTRY
H1	(Gao et al., 2011)	Supported	25	United States
	(Hamidi & Chavoshi, 2018)	Supported	300	Iran
	(Y. Liu et al., 2009)	Supported	209	Finland
	(Lu & Viehland, 2008)	Supported	180	New Zealand
	(Sabah, 2016)	Supported	80	Finland
	(Yadegaridehkordi et al., 2013)	Supported	350	France
	(Yeap et al., 2016)	Supported	900	Malaysia
H2	(Hamidi & Chavoshi, 2018)	Supported	300	Iran
	(Lu & Viehland, 2008)	Supported	180	New Zealand
	(Yadegaridehkordi et al., 2013)	Supported	350	France
	(Yeap et al., 2016)	Supported	900	Malaysia
H3	(Gao et al., 2011)	Supported	25	United States
	(Hamidi & Chavoshi, 2018)	Insignificant	300	Iran
	(Hao et al., 2017)	Supported	292	China
	(Y. Liu et al., 2009)	Supported	209	Finland
	(Lu & Viehland, 2008)	Supported	180	New Zealand
	(Sabah, 2016)	Supported	80	Finland
	(Sarrab et al., 2016)	Supported	806	Palestine
	(Yadegaridehkordi et al., 2013)	Supported	350	France
	(Yeap et al., 2016)	Supported	900	Malaysia
H4	(Gao et al., 2011)	Supported	25	United States
	(Hamidi & Chavoshi, 2018)	Supported	300	Iran
	(Hao et al., 2017)	Supported	292	China
	(Y. Liu et al., 2009)	Supported	209	Finland
	(Lu & Viehland, 2008)	Supported	180	New Zealand
	(Sabah, 2016)	Supported	80	Finland
	(Sarrab et al., 2016)	Supported	806	Palestine
	(Yadegaridehkordi et al., 2013)	Supported	350	France
	(Yeap et al., 2016)	Supported	900	Malaysia
H5	(Hamidi & Chavoshi, 2018)	Supported	300	Iran
	(Y. Liu et al., 2009)	Supported	209	Finland
H6	(Gao et al., 2011)	Supported	25	United States
	(Hamidi & Chavoshi, 2018)	Supported	300	Iran
H7	(Gao et al., 2011)	Supported	25	United States
	(Hamidi & Chavoshi, 2018)	Supported	300	Iran

Key success factors for the adoption of mobile learning in Catalonia

To carry out the case study in Catalonia n expert judgment was carried out with the double objective of validating the previous results and investigating the importance of factors affecting mobile learning in Catalonia. Participants were provided with a dossier that included the following sections: introduction; expert judgement goals; definition of the 5 key groups of factors impacting mobile learning identified above and summarized in Table 40; and a detail of 50 specific factors to classify into different categories, together with a glossary of said factors. Appendix 2 reproduces the dossier provided to the experts in English and Catalan.

To validate the categories identified above by the participants in the expert meeting, the researchers presented the 5 categories with a brief description. Initially, the category of behaviour, attitude and ethics did not include this last part, which was added by consensus. The participants validated the rest of the categories. Then, the participants were asked to prioritize the five categories of factors described above, using a Likert-type scale. The mean and standard deviation of each of the scales are illustrated by the group of experts in Table 40. Overall, participants prioritize the five categories from the most challenging to the lowest impact as follows: leadership; personal character and ethics; digital literacy; pedagogical; and technological resources. Figure 61 visualizes and arranges the experts' priorities as a spider's



web.

Figure 61. Prioritization by expert judgement of the categories of factors affecting mobile learning adoption

A specific recurrent factor in relation to leadership was the importance of collaboration. In general, neither school leaders, university experts nor inspectors felt that technological resources are a substantial obstacle to the adoption of mobile learning. Most of them (60%) rated it as the least relevant category.

The greatest difference between inspectors and university experts concerned the pedagogical factors. University experts considered this category to be the second most significant, whereas inspectors viewed it as least significant.

Table 40. Prioritization of categories affecting mobile learning perceived by experts

CATEGORY OF FACTORS	INSPECTORS' MEAN (*SD*)	SCHOOL LEADERS' MEAN (*SD*)	UNIVERSITY EXPERTS' MEAN (*SD*)	MEAN (*SD*)
Personal character and ethics	3.00 (1.41)	3.50 (0.71)	3.67 (1.15)	3.43 (0.98)
Leadership	5.00 (0.00)	5.00 (0.00)	3.67 (1.53)	4.43 (1.13)
Technological resources	1.50 (0.71)	2.50 (2.12)	1.33 (0.58)	1.71 (1.11)
Pedagogical	3.00 (0.00)	1.50 (0.71)	2.00 (1.00)	2.14 (0.90)
Digital literacy	2.50 (2.12)	2.50 (0.71)	4.33 (0.58)	3.29 (1.38)

The correlation coefficients are all positive and significantly high in the case of university experts and inspectors. Table 41 depicts the Pearson correlation coefficient among groups of participants.

Table 41. Pearson correlation coefficient among groups of participants

	UNIVERSITY EXPERT	INSPECTOR	SCHOOL LEADER
University expert	1		
Inspector	0.741249317	1	
School leader	0.489274892	0.496291667	1

During the next phase of the meeting, the experts were given a list of 50 specific factors and asked to classify them in the different categories previously analyzed. The factors were presented randomly and sorted according to alphabetical order in Catalan. All factors were selected at least once by one of the participants. Some participants selected the same factor in more than one category. Table 42 shows the 50 factors grouped by category of participants and the number of times they were selected.

Table 42. Key factors that affect mobile learning according to relevance

	# FACTOR	INSPECTOR (N=2)	SCHOOL LEADER (N=3)	UNIVERSITY EXPERT (N=2)	TOTAL (N=7)
Teacher's open minds (B. H. Khan, 2005)	40	6	4	2	12
Type and quality of student assessment (Volery & Lord, 2000)	46	6	3	3	12
Resources plan (Fresen & Lesley, 2006)	29	2	4	4	10
Organizational capacity (Orcutt & AlKadri, 2009)	6	1	4	5	10
Clear guidelines and framework (B. H. Khan, 2005)	32	4	4	2	10
Credibility (Kouzes & Posner, 2011)	15	1	4	5	10
Lack of clear vision and mission (Ekberg & Gao, 2018)	50	2	3	5	10
Culture (Goyal et al., 2010; Heide et al., 2002; Moses, 2017; Paroutis & Heracleous, 2013)	30	1	3	5	9
Trust in technology (Ekberg & Gao, 2018)	41	1	4	4	9
Enthusiastic teachers (Fresen & Lesley, 2006)	24	4	4	1	9
Resistance to change (Orcutt & AlKadri, 2009)	48	2	3	4	9
Knowledge construction (Hao et al., 2017)	14	3	3	3	9
Group learning (Fresen & Lesley, 2006)	31	4	3	2	9
Teachers' digital competences (Bocconi et al., 2013)	9	2	3	3	8
E-learning mindset (Fresen & Lesley, 2006)	39	3	2	3	8
Navigation (B. H. Khan, 2005)	1	2	3	2	7
Commitment (Goyal et al., 2010)	10	3	2	2	7
Frequent and constructive feedback to students (Ng & Nicholas, 2013)	26	2	4	1	7
Learning strategies (Goyal et al., 2010)	22	2	2	3	7
Content readiness (Fresen & Lesley, 2006)	17	3	2	1	6
Software (Olafsen & Cetindamar, 2005)	20	2	3	1	6
Communication (Gronn, 1983; Hackman & Johnson, 2013; B. H. Khan, 2005; Moses, 2017; Ng & Nicholas, 2013)	11	2	2	2	6
Device (Soong et al., 2001)	19	2	3	1	6
Better collaboration using online distribution boards (Soong et al., 2001)	8	1	3	2	6
Reluctance to use mobile devices for educational purposes (Fresen & Lesley, 2006)	47	1	2	3	6
Effective training (Ekberg & Gao, 2018)	27	3	1	2	6
Maintain teachers' and student's knowledge skills (Goyal et al., 2010)	38	3	3	0	6
Assessing student learning (Woolf, 2010)	5	0	3	2	5
Instructor technical competence (B. H. Khan, 2005)	18	2	2	1	5
Availability of educational software (Soong et al., 2001)	16	0	4	1	5
Expectations of efficiency and effectiveness (Yoo et al., 2012)	25	1	1	3	5
Conflict and negotiations (B. H. Khan, 2005)	13	1	2	2	5

Personality traits (Fresen & Lesley, 2006)	7	1	3	1	5
Accessibility (Alrasheedi & Capretz, 2015; B. H. Khan, 2005)	2	1	2	2	5
Classroom interaction (B. H. Khan, 2005)	35	2	1	1	4
Distribute responsibility (Eide & Søreide, 2014)	21	2	1	1	4
Lack of incentives (Mercader, 2018)	33	1	2	1	4
Malfunctioning IT (Ekberg & Gao, 2018)	37	1	2	1	4
Strategy formulation (Goyal et al., 2010)	28	1	2	1	4
Teaching practices predefined (Mercader, 2018)	45	0	1	2	3
Student participation (Goyal et al., 2010)	43	1	2	0	3
Usability (B. H. Khan, 2005)	49	1	1	1	3
Adaptability of the course to being taught through ICT (Soong et al., 2001)	3	1	0	2	3
Personalizing education (Woolf, 2010)	44	1	2	0	3
Level of interaction (Rikala, 2015)	42	1	1	1	3
Curriculum (Rikala, 2015)	36	1	1	0	2
Affordability (UNESCO, 2011)	4	1	0	1	2
Key Performance Indicators (Humaidi et al., 2010)	34	1	1	0	2
Connectivity (Alrasheedi & Capretz, 2015)	23	1	1	0	2
Extrinsic motivators: facilitating conditions (B. H. Khan, 2005)	12	0	0	1	1
Total		90	116	96	302

The participants agreed on the classification of at least three factors per category. Table 43 shows the three most frequently included factors in each of the five categories.

Table 43. Key factors that affect mobile learning grouped into categories

Category	Item
Technological resources	Navig0ation (Khan, 2005)
	Software (Olafsen & Cetindamar, 2005)
	Device (Soong, Chan, Chua, & Loh, 2001)
Pedagogical	Credibility (Kouzes & Posner, 2011)
	Learning strategies (Goyal et al., 2010)
	Type and quality of student assessment (Volery & Lord, 2000)
Digital literacy	Type and quality of student assessment (Volery & Lord, 2000)
	Teachers digital competences (Bocconi, Kampylis, & Punie, 2013)
	Credibility (Kouzes & Posner, 2011)
Personal character and ethics	Teacher's open minds (Khan, 2005)
	Resistance to change (Orcutt & AlKadri, 2009)
	Enthusiastic teachers (Fresen & Lesley, 2006)
Leadership	Clear guidelines and framework (Khan, 2005)

	Organizational capacity (Orcutt & AlKadri, 2009)
	Culture (Goyal et al., 2010; Heide, Grønhaug, & Johannessen, 2002; Moses, 2017; Paroutis & Heracleous, 2013)

For the rest of the factors, in the case of discrepancies, the category selected by most participants was used. The Venn diagram illustrated in Figure 62 shows the classification of the above critical success factors affecting mobile learning according to the criteria of the panel of experts. The size of the elements of the Venn diagram represents the prioritization of the different categories represented in Figure 62. The colour scheme distinguishes the soft and hard categories. The categories in red are soft, and the categories in blue are hard.

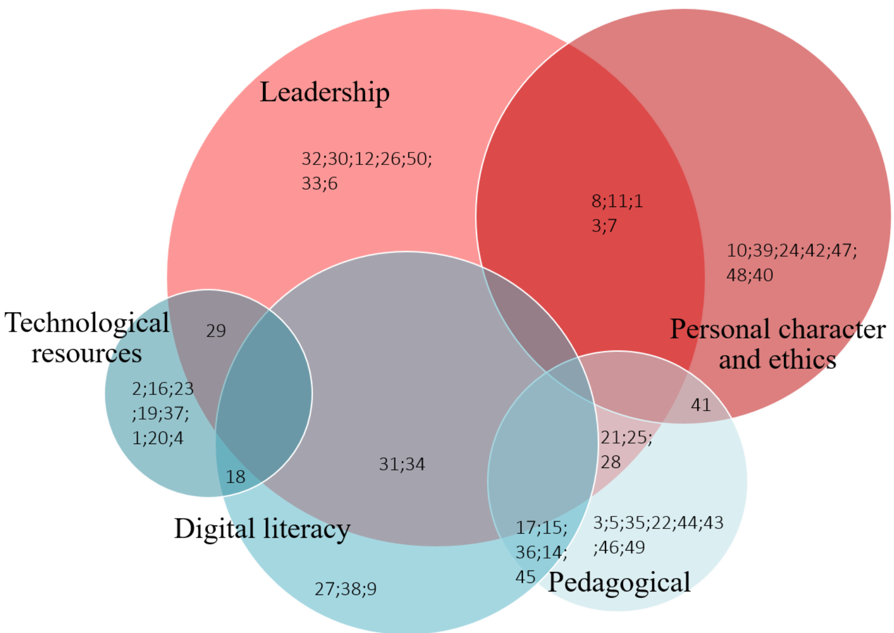


Figure 62. Classification of key factors affecting mobile learning adoption in Catalonia

To identify more qualitative impacts of the mobile learning intervention described in this paper, comments from experts were analyzed. One inspector stated: "*without evaluation, there are no results*". Nationals Spain policies 1:1 was specified in most of Spain's territories through the «School 2.0» program and was cited as an example of the low relevance of

Designing a framework for mobile learning adoption and sustainable development

technological resources. Experts highlighted the fact that the project was mainly focused on technological resources, disregarding other crucial aspects. Additionally, participants commented about the poor quality of resources, mentioning that electronic textbooks were often simply the digital versions of existing print products. These results are consistent with the results from the 1 to 1 Learning study collected by European Schoolnet (EUN) through its network of policymakers, researchers and practitioners from 30 Ministries of Education in Europe (Bocconi et al., 2013).

Another general comment was related to the difficulty of analyzing isolating factors due to the high correlation between them. School leaders highlighted the challenges of adjusting the different levels of technological knowledge among teachers.

The ethical repercussions were among the aspects that were most emphasized by the school leaders. One of them had gone to three trials for three cyber-bullying lawsuits. All the experts agreed on the double need to regulate and limit the use of mobile devices in the classroom from an ethical point of view, such as the importance of having legal support departments.

Designing a framework for mobile learning adoption and sustainable development

5.2. Study 6:" What factors matter most for mobile learning adoption?" [6]

5.2.1. Introduction

This study investigates the interaction among factors affecting the effectiveness and consistency of frameworks for adoption and sustainable use of mobile learning. The research was designed according to a mixed-methods paradigm, including a literature review and a systematic review. A total of 361 factors were identified in the literature review of 75 studies. Twenty-five studies were included in the systematic review. The findings derive a five-discrete-dimension cluster that matter the most in isolation and as an orchestrate scenario: technological resources; digital literacy; pedagogical, behaviour, attitudes and ethics; and leadership. The findings could be useful to any schools which are thinking about introducing or amplifying mobile learning in their curriculum in order to prioritize and manage strategic initiatives.

The objective of this study is to identify and evaluate the critical factors that shaped the adoption and sustainable use of mobile learning. Identifying the main factors influencing the mobile learning and how can enhance or impede effective adoption and sustainable use. Thus, the research question to be answered in this paper is: Which factors determine the success of mobile learning adoption and sustainable use?. The two specific research questions driving this study are.

RQ1. What are the key success factors in integrating mobile learning within education?

RQ2. How key factors affecting mobile learning can be grouped in a communal hierarchical taxonomy?

[6] Moya, S., & Camacho, M. (2019). What factors matter most for mobile learning adoption? *Proceedings of the 15th International Conference on Mobile Learning 2019, ML 2019*, 27–34. Utrecht, The Netherlands. https://doi.org/10.33965/ml2019_201903l004

5.2.2. Methodology

Explanatory sequential design (Creswell 2012) was used to direct different methods and mixed collection data tools were employed with the objective to triangulate and validate research and prove evidence. Table 44 illustrates the research design.

Table 44. Research Design

RESEARCH PURSUED	RESEARCH OBJECTIVE	SAMPLE/ PARTICIPANTS	DATA COLLECTION METHOD
Explanatory	Develop an initial understanding of key factors affecting mobile learning adoption. RQ1. What are the key success factors in integrating mobile learning within education?	N= 75 studies N= 362 Factors identified	Literature review
Explanatory	To collect evidence regarding the cause-and-effect of the most common barriers and enablers of mobile learning. Identify the main categories grouping factors affecting mobile learning adoption in secondary schools. Gather information needed to design the expert judgment. RQ2 How key factors affecting mobile learning can be grouped in a communal hierarchical taxonomy?	N= 27 studies	Systematic review

Search literature was based in concept centric (Okoli & Schabram, 2010; Webster & Watson, 2002). For literature reviews conducted in relation to education, the Web of Science database has been recommended by several previous studies (Fu & Hwang, 2018). With the objective to identify the main factors affecting mobile learning adoption, both mobile learning and strategic management critical factors were included in the research. The expressions (“mobile learning” OR “ubiquitous learning” OR “blended learning” OR “M-learning” OR “B-learning” OR “mobile devices” OR “strategic management” OR “strategic process” OR “strategic planning”) AND (“factors”) were used. The research process initially yielded 242 publications. Results were filtered by timespan between 2008 and 2018, resulting in 203 studies. A total of 75 studies were selected based on titles and reading its abstract and keywords revised, refined and article grouping was adjusted and summarize in a meta-data and concept matrix. Appendix 1 contains the link to access the metadata table.

A systematic review (Hemingway & Brereton, 2009) approach was performed in this study to answer the second research question directing this study with the goals of providing an impartial synthesis, summarize and generalize the relevant knowledge, trends as well as to identify the main categories.

Based on the prior literatdure review research, the following inclusion and exclusion criteria were applied: categorization or grouping was among the key variables of the study and studies must have been published between 2008 and 2019. A total of 35 full texts were identified as eligible for the review and were comprehensively analysed by two of them. Finally, 27 studies were included in the systematic review. Figure 63 shows the data search and collection process. The 27 studies included in this analysis are identified with an asterisk in the bibliography.

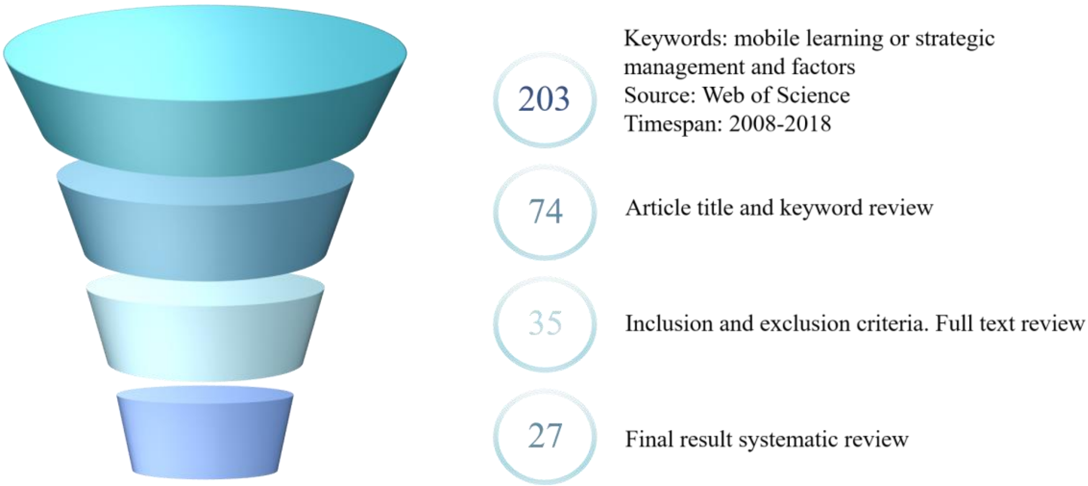


Figure 63. Diagram of the systematic review search process

5.2.3. Results

Factors affecting mobile learning adoption

A There are numerous mobile learning definitions, most of them highlight the core characteristics such as mobility, ubiquity, interaction, learner-centered approach, formative assessment, collaborative sharing and personalization (Osman et al., 2010; Crompton et al.,; Peng et al., 2009; Peters, 2009; Cochrane & Bateman, 2010; Teoh, 2011 Jahnke & Kumar 2014; Alrasheedi & Capretz, 2015; Thinley et al. 2014; Cochrane et al., 2013, Kean et al. 2013). For the purposes of this study, we will define mobile learning as the art of using mobile technologies to empower and enhance learning experiences (Rikala, 2016).

Literature highlights isolated recurrent factors affecting strategic management, and mobile learning. Most of the studies analysed were focused on the perceived performance or learning outcomes. A significant number of the studies analysed were focused on students' or teachers' perceptions. Based on the literature review of 75 studies, 362 different factors have been identified. The most cited factor is communication cited in 10 studies, followed by leadership, highlighted in 6 studies, assimilation with curriculum and institutional support were cited in five and four studies, respectively.

Taxonomies of factors affecting mobile learning adoption

There is significantly consistence amount grouping the factors affecting strategic management in two big categories. On one hand, hard factors, including those impacting company performances in a way that companies can reasonably handle, manage, and measure. This category includes factors such as technological resources, company's structure, managerial skills, strategy, and organization. Some authors call this group hard factors. Hard elements are easier to define or identify and management can directly influence them (Peters & Waterman, 1982). Other frameworks call this category performance factors (Dewar et al., 2011). Other studies group in a similar way called this category independent variables (Humaidi et al., 2017). Some frameworks identify this category as hard or institutional factors (Li, et al., 2008).

On the other hand, soft factors, this second category includes the factors affecting the company's soul, culture and organizational behaviour.in their three main areas: individual, group and organization. This category has often been identified as soft factors. "Soft" elements can be more difficult to describe and are less tangible and more influenced by culture (Peters & Waterman, 2012). Other studies identify this category as health (Dewar, et al., 2011). Other studies group in a similar way called this category dependent variables (Humaidi et al., 2017). This category has also been identified as soft or people-oriented (Li, et al., 2008). Table 45 summarizes the categories of factors affecting strategic management.

Table 45. Categories of factors affecting strategic management process: frameworks and studies

CATEGORY	STUDY WORKING	FRAMEWORK	STUDY
Hard	Hard	7 S framework	Peters & Waterman (1982)
	Hard	8 S framework	Higgings (2005)
	Performance	5 As framework	Dewar et al. (2011)
	Independent	Knowledge Project Management Performance Assessment	Humaidi, Anuar & Azzah Said (2017)
	Hard	A framework of strategy implementation research	Li, Guohui & Martin, (2008)
Soft	Soft	7 S framework	Peters & Waterman (1982)
	Soft	A framework of strategy implementation research	Li, Guohui & Martin, (2008)
	Soft	8 S framework	Higgings (2005)
	Health	5 As framework	Dewar et al. (2011)
	Dependent	Knowledge Project Management Performance Assessment	Humaidi, Anuar & Azzah Said (2017)

Featured in the book by former McKinsey consultants Thomas J. Peters and Robert H. Waterman, Mc Kinsey developed a management framework that maps a constellation of interrelated factors that influence an organization's ability to change. The McKinsey "7S" framework involves seven interdependent factors which are categorized as either "hard" or "soft" elements. "Hard" elements are easier to define or identify and management can directly influence them: Strategy, Structure and Systems. "Soft" elements are more difficult to describe, and are less tangible and more influenced by culture: Shared values, Skills, Style, and Staff. This framework that has persisted over the years according to McKinsey Quarterly report, March 2008. In 2005, Higgins adapted the framework and sets up an "8S" framework of strategy implementation, including strategy and purposes structure, resources, shared values, style, staff, systems and processes, and strategic performance.

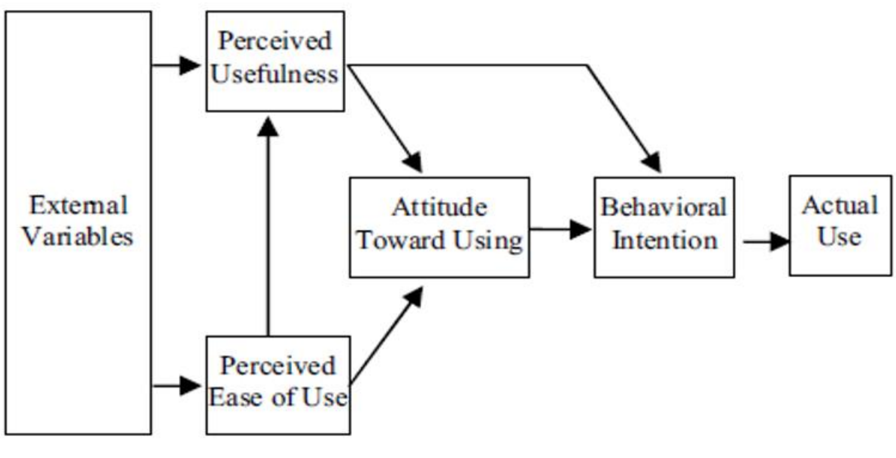
Li, Guohui and Eppler (2008), identified nine recurring factors affecting strategy implementation. They divided those nine factors into three categories: soft, hard, and mixed factors. Soft factors (or people-oriented factors) include the people or executors of the strategy; communication; relationship with different business units; consensus; tactics and commitment to the strategy. Strategy formulation factor is considered a mixed factor containing hard and soft elements (Li, et al., 2008).

The McKinsey "5As" framework, 2011, highlights health as well as performance as the key to sustaining excellence. The framework is based on a structured process characterized as "5As": aspire, assess, architect, act, and advance. For each stage, there are frameworks for performance and health that enable leaders to manage both with the same rigour and discipline. Performance five stages are related to strategic objectives, capacity platform, the portfolio of initiatives, delivery model and continuous improvement, in terms of health, the five stages are health essentials, the discovery process, influence model, change the engine and central leadership (Dewar, et al., 2011).

Humaidi, Anuar and Azzah, developed a conceptual framework grouping factors affecting project management. The framework draws on the bases of T.M. Qureshi. A. S. Warraich and S.T. Hijazi, 2009, included six independent variables (leadership, staff, policy & strategy, partnership & resources, project life-cycle management process and key performance indicators) and one dependent variable (project management performance). They added knowledge as a factor that can cause management performance. The framework was named Knowledge Project Management Performance Assessment (KPMPA) (Humaidi, et al., 2017).

Most of the 27 studies analysed in the systematic review applied a specific model to test user attitude and intention to adopt new technologies. Several models have been identified, including: the theory of reasoned action (TRA) (Fishbein & Ajzen 1975), the technology acceptance model (TAM) (Davis 1989), the theory of planned behaviour (TPB) (Ajzen 1991), and the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh, Morris, Davis & Davis, 2003).

Among the different models, TAM appears to be one of the most used in the studies included in this research. Technology Acceptance Model (TAM) (Davis, 1989) consists of five main elements: perceived usefulness, perceived ease of use, attitude toward using, behavioural intention and actual system use. Perceived usefulness refers to "the degree to



which a person believes that using a particular system would enhance his or her job performance"; and perceived ease of use defined as "the degree to which a person believes that using a particular system would be free from effort" (Davis, 1989). Both are impacted by external variables. Technology Acceptance Model is shown in Figure 64.

Figure 64. Diagram of the systematic review search process

A parallel can be made here with the main categories of factors affecting strategic management analysed above. Variables impacting perceived ease to use are those affecting "the degree to which a person believes that using a particular system would be free from effort" (Davis, 1989).

Based on strategic management factors classification described above (hard and soft); TAM theory classification (perceived easy to use and perceived usefulness); and Teoh (2011) and Alrashedi et al. (2015) studies; five categories were used to analyse the 27 studies included in the systematic review. Three categories of factors (technological resources, pedagogical and digital literacy) derived from hard factors and factors affecting the perception of easy to use. The other two categories (Behaviours, attitudes, and ethics; and leadership) were considered soft factors or factors affecting the perception of usefulness in TAM theory. Table 46 shows the five categories of factors affecting mobile learning adoption and the number of mentions in the 27 studies included in this systematic review.

Table 46. Dimension and Categories of factors affecting mobile learning adoption

DIMENSION	CATEGORY	RECURRENCE IN THE SYSTEMATIC REVIEW
Hard		**72**
	Technological resources	17
	Pedagogical	39
	Digital literacy	16
Soft		**52**
	Behaviours, attitudes, and ethics	23
	Leadership	29
	Total general	124

The first category is related to technological resources, it includes factors such as technological infrastructure, navigation, internet connexion, mobile tools, level of integration, technical support, student-device ratio, or hardware. Other names with which this category is identified are: technological factors (Olafsen, 2005; Goyal et al., 2010; Mahdi, 2017; Sharples 2013; Hao et al., 2017); hard factors (Dublin, 2004); non-human factors (Spector, 2013) and technological infrastructures (Tay et al., 2013).

The Second category encompasses pedagogical factors such as classroom integration, adaptability of the course, assessment, availability of content and software, critical thinking, develop thinking, time management, recognition of informal learning, define target learner groups for m-Learning; teaching preparation, solving problems, design approach, gamification, virtual environments, or customization. Most authors call this category pedagogical factors, pedagogical integration, learning-related or learner's requirement (Graf & Caines, 2004; Olivier, 2005; Goyal et al., 2010; Cochrane & Bateman, 2010; UNESCO, 2011; Johnson, 2011; Yoo et al., 2012; Mahdi, 2017; Hao et al., 2017; Ekberg & Gao, 2017).

A third category refers to educational community's mobile learning skills or digital literacy, to this category belong the following factors: teacher's digital knowledge, training, student's knowledge, teacher's and student's digital competency, teacher's practices, and digital assessment knowledge. Some studies called this category of digital literacy (Johnson et al. 2011; Goyal et al., 2010). Tay et al. (2013) called this dimension of professional development. Yeap et al. (2016) referred to this category as "instructor readiness". Hargreaves and Fullan (2012) emphasize teacher's role in the use of technology for professional learning. Training has pointed out as a crucial factor (Abu Al-Zur & Qablan, 2011; Al Sharija, James & Waters, 2012).

The fourth category integrates human-related factors, focus on individual behaviours, attitudes, and ethics. Often labelled as soft or human factors category (Dublin, 2004; Spector, 2013; Hao et al., (2017), named this category personal and social factors. Yoo et al. (2012), called motivational factors it also includes behaviours and attitudes, teacher's attitudes are decisive in the successful integration of m-learning in teaching. The resistance to change factors represents a significant portion of this category (Spector, 2013; Mercader, 2018).

The fifth category integrates human-related factors, affecting organization and groups, highlighting leadership as the most cited. In educational management, the importance of articulating organizational values is widely acknowledged. Tay, Liam, and Lim (2013) referred to this category as school leadership. Ekberg and Shang (2017) named support from school leadership. Ekberg and Gao, (2017) in their framework place a variable called school leadership.

5.3. Study 7:" Factores que afectan la adopción de mobile learning en Cataluña" [7]

5.3.1. Introducción

El principal objetivo de este estudio es mejorar la adopción y uso sostenible de Mlearning en la enseñanza secundaria de Cataluña, mediante la identificación y análisis de los factores críticos que le influyen. Los objetivos específicos que persigue esta investigación son:

O1. Identificar los factores críticos de éxito para la adopción y el uso sostenible del mobile learning en la educación secundaria.

O2. Analizar cómo se pueden agrupar los factores clave que afectan el mobile learning en una taxonomía jerárquica común.

O3. Identificar qué categorías de factores de éxito se les da más importancia en Cataluña

O4. Analizar la influencia de factores sociodemográficos y contextuales en el impacto de los factores de éxito para la adopción y uso sostenible de Mlearning en Cataluña.

Preguntas de investigación

Basadas en el objetivo principal de este estudio, de mejorar la adopción y uso sostenible de Mlearning en la enseñanza secundaria de Cataluña, mediante la identificación de factores clave, las preguntas de investigación, son las siguientes:

RQ1. ¿Cuáles son los factores críticos de éxito para la adopción y el uso sostenible del mobile learning en la educación secundaria?

RQ2. ¿Cómo se pueden agrupar los factores clave que afectan el mobile learning en una taxonomía jerárquica común?

RQ3. ¿A qué categorías de factores de éxito se les da más importancia en Cataluña?

Hipótesis descriptivas

Numerosos estudios han hecho agrupaciones de factores que afectan la implementación de tecnología en educación. Teoh, (2011) realiza un estudio en profundidad y concluyó que los

[7] Moya, S., & Camacho, M. (2020b). Factores que afectan la adopción de mobile learning en Cataluña. In UMA editorial (Ed.), *XXIII Congreso Internacional Edutec* (pp. 756–762). Málaga, Spain.

principales grupos de factores críticos que afectaban eran relativo a infraestructura; usuario; estrategias pedagógicas y la comunidad educativa. Una encuesta relevante se lleva a cabo en la Universidad Tecnología de Nayang en Singapur, un estudio realizado por (Kong, Chan, Huang, & Cheah, 2014) y hace identificar también cinco categorías: factores humanos, competencia técnica, mentalidad, nivel de colaboración; y la infraestructura de TI percibida. En base a estas investigaciones las hipótesis se basan en las siguientes categorías de factores críticos: pedagógicos, tecnológicos, alfabetización digital, liderazgo y personales y éticos. Los factores que influyen más en la adopción del mobile learning en Catalunya de son los siguientes: tecnológicos, pedagógicos, alfabetización digital, liderazgo, y personalidad, carácter y ética.

Hipótesis asociativas:

Existe relación entre el sexo y la edad y la relevancia de los factores que influyen en la adopción del mobile learning.

Existe diferencia en la identificación de factores que afectan la adopción de Mlearning entre diferentes niveles educativos.

Existe diferencia en la identificación de factores que afectan la adopción de Mlearning en función de los años de experiencia de los profesores.

Existe diferencia en la identificación de factores que afectan la adopción de Mlearning en función del tipo de centro: público, concertado o privado.

5.3.2. Metodología

El paradigma de esta investigación es interpretativo, el proceso ha sido la encuesta y principal instrumento metodológico ha sido el cuestionario transversal. La variable dependiente son los factores que afectan la adopción de Mlearning en Catalunya. Existen diferentes variables dependientes como son el género, la formación, la antigüedad, la condición socioeconómica del centro, la planificación del centro en materia digital.

Participantes

La población de la investigación son los maestros y profesores de primaria y secundaria en Catalunya, en el año 2017 eran 71.000 profesores. La investigación se centra en el contexto de las escuelas secundarias catalanas en la primavera de 2019. Según la Generalitat de Catalunya, Xarxa Telemàtica Educativa de Catalunya, en 2017, Cataluña tenía 1.088 escuelas de secundaria, incluidas 567 escuelas públicas (52%) y 521 privadas o concertadas (48%). La ratio entre profesores y alumnos en ESO y bachillerato era de 11.9 en el año 2017 según el instituto de estadística de Catalunya, IESCAT, tal como muestra la Table 47.

Table 47: Alumnado y profesorado de Catalunya curso escolar 2017-2018. Fuente: Instituto de estadística de Catalunya (IDESCAT)

	ALUMNOS	PROFESORES
ESO	323.334	
Bachillerato	92.584	
Formación profesional	120.314	
Total	**536.262**	**44.892**

Dadas las dificultades de acceso a la población, la técnica de muestreo ha sido no probabilística, asumiendo los riesgos de sesgo de representatividad. Todos los sujetos han participado por voluntad en la encuesta. Como muestra la Table 488, el número de encuestas necesarias para obtener un nivel de confianza del 95% debería ser de 302 encuestas.

Table 48 Estimación de la muestra para niveles de confianza del 95% con precisión del 3%

INDICADOR	UNIDAD	VALOR
Población	(N)	44.892
Nivel de confianza	(1-α)	95%
Precisión	(d)	3%
Proporción	(p)	5%
Tamaño de la muestra	(n)	202

Dimensiones

Numerosos estudios han justificado agrupaciones de factores que afectan la implementación de tecnología en educación. Teoh (2011) realizó un estudio en profundidad y concluyó que los principales grupos de factores críticos que afectaban eran relativos a infraestructura; usuario; estrategias pedagógicas y la comunidad educativa.

En la Universidad Tecnología de Nayang en Singapur, un estudio realizado por Soong et al. (2001) reveló cinco categorías: factores humanos, competencia técnica, mentalidad, nivel de colaboración; y la infraestructura de TI percibida. En base a estas clasificaciones este estudio analiza los factores clave que afectan a la adopción de mobile learning, utilizando las siguientes agrupaciones: recursos tecnológicos, aspectos pedagógicos, alfabetización digital, comportamientos, actitudes y ética, y liderazgo.

El diseño del cuestionario se ha basado en estas categorías asignando entre tres y cuatro preguntas a cada dimensión. La Table 49 muestra la relación entre las preguntas y las variables.

Table 49. Relación entre preguntas del cuestionario y variables

RECURSOS TECNOLÓGICOS
Tecnológicos
Disponibilidad de software y recursos es esencial para la adopción de dispositivos móviles en las aulas
La navegación y conectividad a internet es crucial para implementar el uso de dispositivos móviles en las aulas
Tener una buena herramienta digital es indispensable para adoptar el mobile learning
Alfabetización digital
Formación y mantener las competencias digitales es prioritario para la adopción del mobile learning
La competencia digital de los docentes se debe evaluar para garantizar la adopción del mobile learning
La comunidad educativa debe ser competente en tecnologías digitales para adoptar el mobile learning
Pedagógicos
La adopción del mobile learning requiere estrategias pedagógicas adecuadas
La evaluación debe adaptarse para evaluar a los estudiantes para poder adoptar el mobile learning
Sin una buena evaluación inclusiva la adopción de mobile learning no es factible
Comportamientos, actitudes i ética
La adopción del mobile learning requiere altos niveles de compromiso por parte de toda la comunidad educativa
La ética y los problemas morales de la utilización de tecnología digital deben estar regulados y controlados
La resistencia al cambio es uno de los factores determinantes a la hora de implementar el mobile learning
Una actitud positiva y voluntad de cambio es importante para garantizar la adopción del mobile learning
Liderazgo
Guías y estrategias claras a toda la comunidad educativa, son importantes para la adopción del aprendizaje con dispositivos móviles

La comunicación y colaboración son fundamentales para adoptar el mobile learning
Tener protocolos y pautas bien definidos es imprescindible para la adopción del mobile learning
Una cultura que promueva la adopción de dispositivos móviles es un factor clave para que la adopción sea un éxito

Instrumentos / Materiales

El principal instrumento de recogida de datos es el cuestionario con preguntas cerradas, tipo Likert con cinco puntos y únicamente incluye una pregunta abierta. La escala Likert consta de cinco puntos, donde el cinco se refiere a la máxima actitud favorable: "completamente de acuerdo o muy satisfecho" i 1 a la mínima "completamente en desacuerdo o muy insatisfecho". El cuestionario tiene dos secciones: datos sociodemográficos y factores que afectan la integración de Mobile Learning. La primera sección incluye 9 preguntas y la segunda 18. El Anexo 1 reproduce las 27 preguntas del cuestionario en catalán y el Anexo 3 en castellano. El cuestionario ha sido validado por un experto en cuanto a pertinencia e importancia de las diferentes variables. La validación del instrumento fue positiva. El índice Alfa de Cronbach muestra un nivel de confiabilidad muy elevado (0.98).

Procedimiento

El procedimiento de distribución del cuestionario y recogida de datos ha sido digital utilizando Microsoft Forms se puede acceder a una copia en la siguiente dirección URL: https://bit.ly/2I5Qqrl. El Apéndice 3 incluye los documentos utilizados durante el proceso de elaboración y distribución del cuestionario.

Estrategias de distribución

Fundamentalmente dos estrategias han sido utilizadas para distribuir el cuestionario:

(1) Redes sociales se ha hecho la búsqueda basada en palabras clave como profesores, maestros, interinos, oposiciones, bolsas de traslado, concertada y escuelas privadas. Las plataformas han sido Facebook, Instagram y Twitter. El Apéndice 3 incluye la tabla donde se detallan los diferentes grupos,

(2) Emailing a 50 centros educativos de catalunya. Se han seleccionado 20 por provincia, con la excepción de Barcelona que han sido 30 y se ha mantenido la proporción entre centros públicos y concertados. El Apéndice 3 muestra el detalle de los centros.

También en el Apéndice 3 se encuentra un ejemplo de email enviado al profesorado para solicitar su participación en el cuestionario.

5.3.3. Resultados

El análisis de datos se ha realizado utilizando el programa PSPP. El tipo de pruebas realizadas son de tipo descriptivas (medias y desviaciones), de comparación (prueba de Chi2), de diferencias (prueba ANOVA) y de correlación (correlación de Pearson).

Perfil de los participantes

El género del profesorado que ha contestado el cuestionario es el femenino (74%). Este dato es consecuente con la realidad, según los indicadores del personal al servicio de la administración educativa, el personal docente en centros públicos un 75% son mujeres y un 25% son hombres. Esta diferencia se acentúa en infantil y primaria donde el tanto por ciento es del 85% i el 64% en secundaria para el curso 2017-2018.

Las edades de los participantes oscilan entre 25 y 60 años. La media de edad se sitúa en los 41.5 años, con una desviación estándar de 10.3 años. No existe diferencia significativa entre género, la edad media del profesorado que ha contestado el cuestionario de las mujeres es de 42.1 años y los hombres 42.3. La Table 50 recoge los datos relacionados con el género y edad. Y la Table 51 los años de experiencia.

Table 50. Relación entre género y edad

GÉNERO	N	MÁX.	MIN.	PROMEDIO	DESV. ESTÁNDAR
Mujer	110	60	25	42.1	9.8
Hombre	37	64	33	42.3	10.3
TOTAL	**147**	**64**	**29**	**42.2**	**9.7**

Table 51. Distribuciones SPSS

AÑOS DE	N	MÁX.	MIN.	PROMEDIO	DESV. ESTÁNDAR
Mujer	110	60	25	42.1	9.8
Hombre	37	64	33	42.3	10.3
TOTAL	**147**	**64**	**29**	**42.2**	**9.7**

En el caso de la experiencia docente, el 25% de los encuestados tienen menos de dos años de experiencia, el 11% entre dos y cinco años, el 28.5% entre cinco y diez y el 36% más de diez años de experiencia docente. En relación con el nivel educativo donde ejercen la docencia, el 49% de los docentes que han contestado el cuestionario es profesor de infantil y primaria y el 51% de secundaria. Finalmente, el 40% de los docentes ejercía la docencia en centros concertados y el 60% en centros públicos.

Importancia de los factores en la implementación del mobile learning

Los resultados sobre la importancia de los posibles factores que afectan a la implementación del mobile learning se basan en las diferentes afirmaciones que propone el cuestionario representando las cinco categorías de factores: recursos tecnológicos, aspectos pedagógicos, alfabetización digital, comportamientos, actitudes y ética, y liderazgo. Las respuestas de las diferentes preguntas se han agrupado en las cinco categorías principales según la media. La Table 52 muestra las frecuencias según el grado de acuerdo de los factores que afectan a la adopción de mobile learning en las aulas. Se han sombreado los porcentajes más altos de cada factor, la moda de cada factor. En la mitad de la muestra, la moda supera el 50%. Lo que indica que más de la mitad de la muestra está muy de acuerdo que ocho de los 17 factores propuestos son relevantes para la adopción de mobile learning.

Table 52. Frecuencias del grado de acuerdo de los factores que afectan a la adopción de mobile learning

	MUY DE ACUERDO	BASTANTE DE ACUERDO	ALGO DE ACUERDO	POCO DE ACUERDO	NADA DE ACUERDO
Tener una buena herramienta digital es indispensable para adoptar el mobile learning	15.3%	37.6%	31.9%	9.0%	6.2%
La adopción del mobile learning requiere estrategias pedagógicas adecuadas	57.0%	16.0%	20.0%	2.0%	5.0%
Una actitud positiva y voluntad de cambio es importante para garantizar la adopción del mobile learning	50.0%	21.4%	23.2%	0.4%	5.0%
Formación y mantener las competencias digitales es prioritario para la adopción del mobile learning	25.7%	35.0%	29.3%	6.4%	3.6%
La ética y los problemas morales de la utilización de tecnología digital deben estar regulados y controlados	56.0%	23.3%	9.7%	3.0%	8.0%
Disponibilidad de software y recursos es esencial para la adopción de dispositivos móviles en las aulas	25.0%	35.2%	29.5%	6.6%	3.8%
La navegación y conectividad a internet es crucial para implementar el uso de dispositivos móviles en las aulas	20.0%	36.4%	30.7%	7.9%	5.0%
La evaluación debe adaptarse para evaluar a los estudiantes para poder adoptar el mobile	31.0%	33.7%	28.0%	5.1%	2.3%

learning					
La competencia digital de los docentes se debe evaluar para garantizar la adopción del mobile learning	27.6%	34.5%	28.8%	6.0%	3.1%
La adopción del mobile learning requiere altos niveles de compromiso por parte de toda la comunidad educativa	37.0%	32.2%	26.5%	3.6%	0.8%
Guías y estrategias claras a toda la comunidad educativa, son importantes para la adopción del aprendizaje con dispositivos móviles	38.0%	31.9%	26.2%	3.4%	0.5%
Tener protocolos y pautas bien definidos es imprescindible para la adopción del mobile learning	57.0%	27.2%	3.8%	7.0%	5.0%
Una cultura que promueva la adopción de dispositivos móviles es un factor clave para que la adopción sea un éxito	58.0%	26.9%	7.1%	5.0%	3.0%
Sin una buena evaluación inclusiva la adopción de mobile learning no es factible	50.0%	28.9%	9.1%	8.0%	4.0%
La resistencia al cambio es uno de los factores determinantes a la hora de implementar el mobile learning	57.0%	27.2%	7.8%	5.0%	3.0%
La comunicación y colaboración son fundamentales para adoptar el mobile learning	52.0%	28.4%	14.6%	3.0%	2.0%
La comunidad educativa debe ser competente en tecnologías digitales para adoptar el mobile learning	23.4%	35.6%	29.9%	7.0%	4.2%

Los porcentajes más altos en la columna de “muy de acuerdo” corresponden a cultura del centro (58%), resistencia al cambio (57%), protocolos y guías (57%) y estrategias pedagógicas (57%). Por otro lado, los porcentajes más bajos corresponden a herramientas digitales (15.3%) y navegación y conectividad (20%).

Importancia de las categorías de factores en la implementación del mobile learning

La Table 53 nos agrupa las frecuencias descritas anteriormente según las dimensiones identificadas en la fase metodológica. La categoría de factores que más afecta según la muestra es la alfabetización digital (51%) muy de acuerdo, seguido de factores relativos a liderazgo (50%), comportamiento, actitudes y ética (49%). Las otras dos categorías, la moda está en la categoría de bastante de acuerdo: pedagógicos (36%). y recursos tecnológicos (36%).

Table 53. Frecuencias del grado de acuerdo de las categorías de factores que afectan a la adopción de mobile learning

	MUY DE ACUERDO	BASTANTE DE ACUERDO	ALGO DE ACUERDO	POCO DE ACUERDO	NADA DE ACUERDO
Recursos tecnológicos	20%	36%	31%	8%	5%

Alfabetización digital	26%	35%	29%	6%	4%
Pedagógicos	46%	26%	19%	5%	4%
Comportamientos, actitudes i ética	50%	26%	17%	3%	4%
Liderazgo	51%	29%	13%	5%	3%

La prueba del Chi2 reflejada en la tabla 48 muestra la probabilidad de relación entre dos variables. El nivel de correlación de Pearson para la variable edad, es positiva (0.75) y los resultados de la prueba de chi2, muestran una relación significativamente alta para los resultados de factores pedagógicos (0.83), es decir, cuando aumenta la edad, aumenta la valoración del grupo de factores relacionados con factores pedagógicos. También destaca el valor de los años de experiencia y los factores relacionados con la alfabetización digital (0.59), la correlación en años de experiencia según el coeficiente de Pearson es también positiva (0.73) por lo tanto, a más años de experiencia, más se consideran relevantes los factores relacionados con la alfabetización digital tal como muestra la Table 54.

Table 54. Significación de la prueba Chi2 en las variables sociodemográficas

	GÉNERO	EDAD	NIVEL EDUCATIVO	AÑOS DE EXPERIENCIA	TIPO DE CENTRO
Recursos tecnológicos	0.57	0.2	0.16	0.11	0.5
Alfabetización digital	0.21	0.52	0.25	0.59	0.86
Pedagógicos	0.37	0.83	0.37	0.12	0.17
Comportamientos, actitudes i ética	0.21	0.47	0.42	0.37	0.42
Liderazgo	0.20	0.63	0.59	0.12	0.4

En relación con el género, existe poca varianza agrupada (0.0235) y las relaciones no son significativas. La Table 55 permite identificar las categorías de factores que afectan más en función del nivel educativo que imparten los docentes. Los docentes de primaria destacan la categoría de factores pedagógicos (52%) y valoran más las categorías de alfabetización digital (30%) y recursos tecnológicos (23%), en comparación con los docentes de secundaria que ponderan las categorías de factores relativas al comportamiento, actitudes y ética (54%), y liderazgo (57%). La Table 56 muestra los resultados de la prueba de correlación de Pearson, alta (0.81625).

Table 55. Frecuencias del grado de acuerdo de los factores que afectan a la adopción de mobile learning según el nivel educativo

	INFANTIL Y PRIMARIA	SECUNDARIA
Recursos tecnológicos	23%	17%
Alfabetización digital	30%	21%
Pedagógicos	40%	52%
Comportamientos, actitudes i ética	54%	46%
Liderazgo	57%	46%

Table 56. Prueba de correlación de Pearson niveles educativos

	INFANTIL Y PRIMARIA	SECUNDARIA
Infantil y primaria	1	
Secundaria	0.81625	1

Diferencias de género en la valoración de la variable resistencia al cambio

Se ha realizado un contraste entre variables independientes para determinar las diferencias entre hombres y mujeres en la percepción de la relevancia de la resistencia al cambio. Para ellos se ha realizado la prueba F para varianza de dos muestras utilizando Excel. La Table 57 nos muestra que el valor estadístico de contraste observado (0.257) es menor que el valor crítico (0.427), por lo tanto, podemos concluir la aceptación de la hipótesis nula, es decir, no existen diferencias significativas en la percepción de la influencia en la resistencia al cambio.

Table 57. Prueba F de varianza de dos muestras

	MUJERES	HOMBRES
Media	4.69	3.9
Varianza	0.22	0.86
Observaciones	26	9
Grados de libertad	25	8
F	0.257	
P(F<=f) una cola	0.00423	
Valor crítico para F (una cola)	0.4278	

Análisis cualitativo

La última y única pregunta abierta del cuestionario, preguntaba directamente sobre los factores que afectan a la adopción de mobile learning: "¿Qué factores crees que son los más relevantes para adoptar el aprendizaje con dispositivos móviles?". La palabra más repetida fue formación, un 21% de las respuestas la incluían, estos resultados son consistentes con los resultados cualitativos de destacar la formación del profesorado como de mayor incidencia. Cuando los profesores y maestros se refieren a formación, especifican algunos factores como las herramientas, el seguimiento, la metodología, motivación y colaboración:

> *"Formación clara y concisa que repercuta en la motivación del profesorado; herramientas digitales sencillas y atractivas, que se puedan utilizar con los recursos actuales de los centros (tabletas donde se conecten fácilmente los programas, por ejemplo)"*

> *"Motivación, formación, unificación de los aprendizajes con dispositivos móviles"*

> *"la motivación, ya que lleva a la actualización en cuanto a nuevos aprendizajes y al compromiso"*

El segundo bloque de palabras más repetidas ha sido las relacionadas con la seguridad y la ética como: regulación, normativa, control, legislación, límites, responsabilidad, ética, protocolos de actuación, seguridad. Un 17% de las respuestas abiertas han hecho referencia a este concepto.

> *"Inculcar un uso responsable de las nuevas tecnologías"*
>
> *"Normas. Ética. Compromiso. Responsabilidad."*
>
> *"La implementación y seguimiento de normas claras y protocolos de actuación"*
>
> *"Eines de control per assegurar el treball a classe, bloqueig de facebook, instagram, wathsapp, control del que realment volem treballar"*

5.4. Study 8:" Dashboard for monitoring the adoption of mobile learning in education" [8]

5.4.1. Introduction

En un entorno donde la digitalización del mundo es incuestionable e imparable y los niveles de penetración y funcionalidad de dispositivos móviles están alcanzando niveles elevadísimos, el aprendizaje móvil se presenta como un catalizador de aprendizaje a maximizar. La literatura evidencia múltiples resultados positivos en la aplicación de mobile learning, tanto a nivel cognitivo como a nivel afectivo. A pesar de ello, continúa sin estar implementado y cuando lo está, a mendo no es de manera eficiente, también se ha evidenciado una escasez significativa en modelos teóricos para la adopción de mobile learning. El principal objetivo de esta investigación es analizar la utilización del aprendizaje con dispositivos móviles mediante el diseño de un prototipo para valorar la calidad de la adopción del aprendizaje con dispositivos móviles en un centro educativo. Para ello se han desarrollado las dos primeras fases de metodología Design-Based Research (DBR). Durante la primera fase se ha realizado una revisión de la literatura con el objetivo de identificar el problema de investigación, los objetivos y las preguntas de investigación. En una segunda fase se ha realizado una revisión sistemática de la literatura de 20 estudios para identificar los principios de diseño en el ámbito de mobile learning, asimismo, se ha presentado un primer prototipo de cuadro de mando para la evaluación y seguimiento de la adopción de mobile learning. El principal resultado de esta investigación es un modelo de cuadro de mando para que los centros educativos de primaria y secundaria puedan evaluar la calidad de la adopción de mobile learning, ajustar y hacer seguimiento. El modelo se fundamenta en cinco dimensiones clave para posicionar la correcta adopción de aprendizajes con dispositivos móviles: pedagógica; tecnológica; contextual y espacial; transaccional y estratégica. Se sugiere que futuras investigaciones desarrollen instrumentos específicos de recogida de datos para validar el modelo en diferentes contextualizaciones .

[8] Moya, S., Camacho, M., & Palau, R. (2020). Cuadro de mando para el seguimiento en la adopción del mobile learning en educación. In U. A. de Barcelona (Ed.), *VI Congreso Internacional EDO 'La nueva gestión del conocimiento'*.

El principal objetivo es identificar los principales constructos que dimensionan los modelos teóricos para la adopción de mobile learning y diseñar un prototipo para valorar la calidad de la adopción.

5.4.2. Methodology

Este estudio se estructura en base a un procedimiento derivado de la Design-Based Research (DBR) (McKenney & Reeves, 2014). Para el desarrollo de la primera fase del DBR, el método operativo que se ha utilizado ha sido una revisión sistemática de la literatura siguiendo el proceso propuesto por Okoli & Schabram (2010). Los criterios de inclusión y exclusión han sido los siguientes:

(1) Incluir los artículos que incluyan los términos de búsqueda descritos anteriormente.
(2) Incluir sólo estudios en el ámbito genérico de la educación, se han excluido aprendizajes específicos.
(3) Excluir funcionalidades y aplicaciones, como realidad aumentada.
(4) Exclusión de artículos con diseños muy técnicos de aplicaciones o sistemas.
(5) Excluir estudios relacionados con actitudes y percepciones.

El proceso de selección se ha basado de estudios se ha basado en el propuesto por (Yousra Banoor et al., 2019) tal como se ilustra en la figura 64.

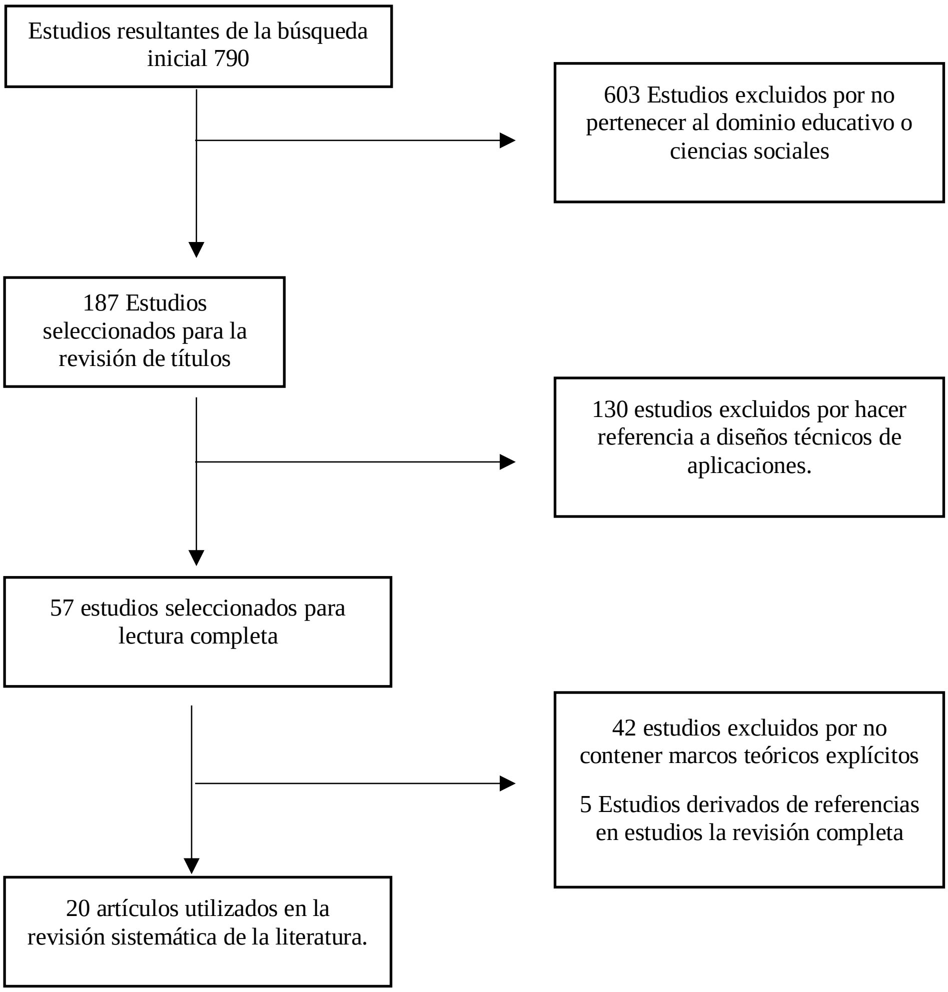


Figure 65. Proceso de selección de estudios, adaptado de (Yousra Banoor et al., 2019)

Después de aplicar los criterios de inclusión y exclusión, el número total de estudios seleccionados ha sido de 20 según muestra la Tabla 58.

Table 58. Marcos Teóricos para la Adopción de Mobile Learning

ESTUDIO	MARCO TEÓRICO PARA LA ADOPCIÓN DE MOBILE LEARNING
(Mishra & Koehler, 2006)	Technological Pedagogical Content Knowledge (TPACK)
(Motiwalla, 2007)	A m-learning framework
(H. Liu et al., 2008)	Design framework for mobile learning

(Peng et al., 2009)(Peng et al., 2009)	The conceptual framework of ubiquitous knowledge construction
(Koole, 2009)	The framework for the rational analysis of mobile education (FRAME)
(Sharples & Vavoula, 2009)	M3 evaluation framework
(Puentedura, 2009)	Situation, augmentation, modification, redefinition
(Nordin et al., 2010)	A framework for mobile learning design requirements for lifelong learning
(Park, 2011)	Four types of mobile learning: a pedagogical framework
(Brummelhuis & van Amerongen, 2011)	The four in balance monitor
(Kearney et al., 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 et al., 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 et al., 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)	Mlearning integration framework
(Ada, 2018)	Mobile Learning Framework for Assessment Feedback

5.4.3. Results

El promedio de antigüedad de los 20 estudios analizados en la revisión sistemática es de 7 años, los más antiguos son del año 2011 y los más recientes del año 2018. El Apéndice 1 contiene el enlace para acceder a la tabla de metadatos.

La mayoría de los estudios analizados han sido publicados en revistas prestigiosas del ámbito de la educación tecnológica. Cuatro de ellas se encuentran en el primer cuartil de la categoría “Education and Educational research” según Journal Impact factor de Web of Science año 2018.

Entre los 20 modelos analizados únicamente cuatro incluyen expresamente la evaluación (Ada, 2018; Churchill et al., 2016; Hwang, 2014; Ng y Nicholas, 2013).

Para identificar las principales dimensiones utilizadas por los diferentes modelos para la adopción de mobile learning, se han utilizados los constructos utilizados explícitamente por seis estudios que han analizado diferentes modelos descritos en el marco teórico de esta investigación, En base al análisis de estas categorías, se han propuesto cinco dimensiones que recogen y sintetizan cada una de las categorías anteriores tal como muestra la tabla 59.

Table 59. Principales Codificaciones de las Dimensiones de los Marcos Teóricos de Mobile Learning

DIMENSIÓN	DESCRIPCIÓN. TRADUCCIÓN PROPIA
Pedagógica	A través del tiempo (Wong y Looi, 2011); Abarcando múltiples modelos pedagógicos de mobile learning (Wong y Looi, 2011); Aprendizaje formal e informal (Wong y Looi, 2011); Autenticidad, situacional y contextualización (Burris, 2017); Cambio continuo entre múltiples tareas de aprendizaje (Wong y Looi, 2011); Centrado en el alumno (Khaddage et al., 2016); Construcción psicológica (Hsu y Ching, 2015) Diseño / evaluación de pedagogías y entornos de aprendizaje (Hsu y Ching, 2015) Diseño de pedagogías y entornos de aprendizaje (Hsu y Ching, 2015) ; En cualquier momento (Traxler, 2010); Pedagogías y diseño de entornos de aprendizaje (Hsu y Ching, 2015) ; Síntesis del conocimiento (Wong y Looi, 2011); Todos pueden producir aprendizaje (Traxler, 2010);
Tecnológica	Tecnología (Hsu y Ching, 2015); Uso combinado de múltiples tipos de dispositivos (Wong y Looi, 2011);
Contextual y espacial	A través de ubicaciones (Wong y Looi, 2011); Abarcando mundos físicos y digitales (Wong y Looi, 2011); Acceso múltiple y a los recursos de aprendizaje (Wong y Looi, 2011); Autenticidad, situacional y contextualización (Burris, 2017); Diseño de plataforma / sistema (Hsu y Ching, 2015) ; En cualquier lugar (Traxler, 2010); Fusionando mundos digitales y físicos (Klopfer et al., 2002)Justo a tiempo (Traxler, 2010)Pedagogías y diseño de entornos de aprendizaje (Hsu y Ching, 2015) ; Portabilidad (Klopfer et al., 2002); (Khaddage et al., 2016); Ubicuo (Khaddage et al., 2016); Uso del tiempo y el espacio (Burris, 2017);
Transaccional	Aprendizaje personalizado y social (Wong y Looi, 2011); Colaboración (conversación e intercambio de datos) (Burris, 2017); Individualizado (Khaddage et al., 2016); Interactividad social y conectividad (Klopfer et al., 2002); Pedagogías y diseño de entornos de aprendizaje (Hsu y Ching, 2015); Solo para ellos (Traxler, 2010)
Estratégica	(Brummelhuis y van Amerongen, 2011; Khalid et al., 2015; Ng y Nicholas, 2013; Peng et al., 2009)

Para la diseñar un modelo de evaluación la calidad de la adopción de mobile learning, este estudio se fundamenta en indicadores que miden las cinco dimensiones identificadas en el apartado anterior: pedagógica, tecnológica, contextual-espacial, transaccional y estratégica. Para ello, se han analizado, además de los 20 marcos teóricos incluidos en la revisión sistemática, estudios adicionales derivados de la revisión de la literatura. La tabla 60 muestra la relación de indicadores para evaluar las diferentes dimensiones identificadas para la adopción de mobile learning en educación.

Table 60. Indicadores para la evaluación de las principales dimensiones para la adopción de mobile learning

DIMENSIÓN	INDICADOR	ESTUDIOS
Pedagógica	Adaptación de materiales de aprendizaje ML	(Brummelhuis y van Amerongen, 2011, Mishra y Koehler, 2006)
	Adaptación específica evaluación de ML. Instrumentos de evaluación	(Ada, 2018, Churchill et al., 2016, Hwang, 2014, Khalid et al., 2015)
	Formación específica ML	(Ada, 2018, Lim Abdullah et al., 2013)
	Planificación de actividades de ML en las aulas	(Ada, 2018, Churchill et al., 2016, Koole, 2009, Mishra y Koehler, 2006, Ng y Nicholas, 2013, Nordin et al., 2010, Peng et al., 2009, Puentedura, 2009, Rikala, 2015, Sharples y Vavoula, 2009, Veerabhadram et al., 2012)
	Ratio participación profesor/alumno	(Crompton, 2017, Rikala, 2015)
	Soporte específico pedagógico para ML	(Churchill et al., 2016, Crompton, 2017, Hwang, 2014)
Tecnológica	Fiabilidad de las conexiones	(Crompton, 2017, Hwang, 2014, Liu et al., 2008)
	Ratio de dispositivos móviles incluyendo BYOD	(Ada, 2018, Brummelhuis y van Amerongen, 2011, Churchill et al., 2016, Khalid et al., 2015, Koole, 2009, Mishra y Koehler, 2006, Nordin et al., 2010, Peng et al., 2009, Puentedura, 2009, Rikala, 2015, Sharples y Vavoula, 2009, Veerabhadram et al., 2012)
	Soporte específico tecnológico para ML	(Lim Abdullah et al., 2013, Ng y Nicholas, 2013)
Contextual y espacial	Aprendizaje formal e informal	(Liu et al., 2008)
	Contextualización del aprendizaje auténtico y situado	(Kearney et al., 2012, Khalid et al., 2015, Nordin et al., 2010, Peng et al., 2009, Rikala, 2015)
Transaccional	Aprendizaje social a través de dispositivos, (ej. debates virtuales)	(Ada, 2018, Crompton, 2017, Kearney et al., 2012, Koole, 2009, Lim Abdullah et al., 2013, Motiwalla, 2007, Ng y Nicholas, 2013, Park, 2011, Rikala, 2015, Sharples y Vavoula, 2009, Veerabhadram et al., 2012)
	Personalización del aprendizaje	(Ada, 2018, Hwang, 2014, Kearney et al., 2012, Koole, 2009, Liu et al., 2008, Motiwalla, 2007, Veerabhadram et al., 2012)
	Construcción cooperativa de conocimiento	(Churchill et al., 2016, Motiwalla, 2007)
Estratégica	Planificación estratégica de la adopción de ML	(Brummelhuis y van Amerongen, 2011, Khalid et al., 2015, Ng y Nicholas, 2013, Peng et al., 2009)
	Definir políticas y procesos	(Ng y Nicholas, 2013)
	Proporcionar apoyo por parte del equipo directivo	(Ng y Nicholas, 2013)

Un total de 14 indicadores extraídos de la revisión sistemática sintetizan los principales elementos de cada una de las cinco dimensiones tal como se muestra en la Figura 65.

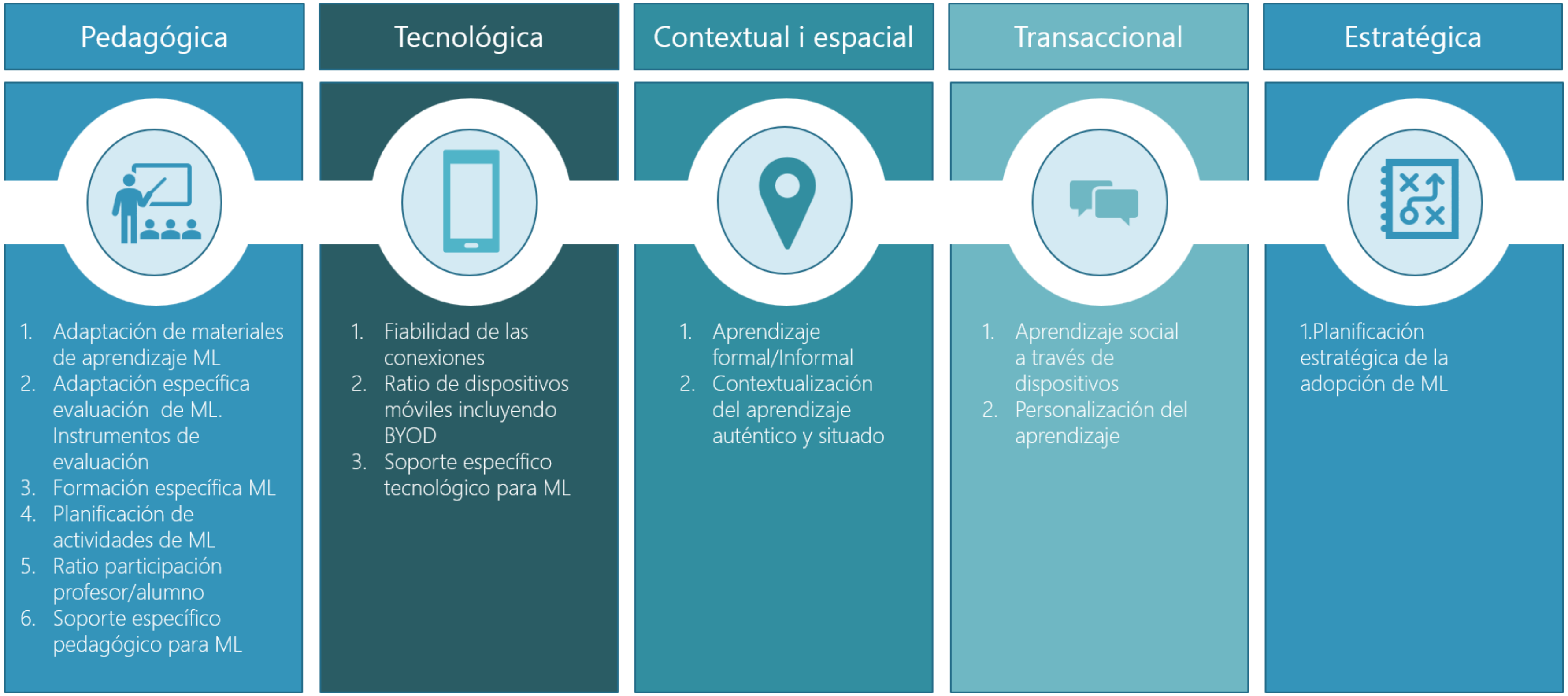


Figure 66. Relación entre dimensiones e indicadores para evaluar la calidad de la adopción de mobile learning

La investigación sobre cuadros de mando tiene como objetivo identificar qué datos son significativos para los diferentes miembros de la comunidad educativa y cómo se pueden presentar estos datos para apoyar los procesos de comprensión y adopción (Schwendimann, 2016). En base a las dimensiones e indicadores anteriormente identificados, se ha diseñado un prototipo de cuadro de mando para el seguimiento y adopción de mobile learning, donde se muestran los datos de cada indicador recopilados durante a un mes en concreto, así como la evolución con relación al mes anterior. En el centro del cuadro de mando, se han situado los niveles de participación directa de los principales responsables y una representación gráfica del nivel global de calidad de la adopción de mobile leaning. En la parte derecha del cuadro de mando para evaluar la calidad de la adopción de mobile learning se muestra la evolución con relación a los objetivos marcados. Todos los datos se expresan en escala de uno a diez.

CHAPTER 6

DESIGN CYCLE FOUR: IMPROVED MOBILE LEARNING FRAMEWORK BASED ON REFINED DESIGN PRINCIPLES

In this Chapter, the fourth and last phase of educational design-based research developed. The objective of the fourth and final phase of the DBR process is Reflection to produce "design principles" and enhance solution implementation (Herrington et al., 2007). During this phase, the first prototype designed based on the design principles identified in phase two (Chapter 3), is refined and adjusted according to the results obtained from the three iterations carried out during phase three (Chapter 4). This chapter answers the last research question RQ6. What are the core elements of a strategic framework for the adoption of mobile learning?

6.1. Study 9 " A framework for mobile learning adoption and sustainable development"[9]

6.1.1. Introduction

This study aims to investigate the main characteristics of a strategic framework for the adaption and sustainable adoption of mobile learning. This study is based on a systematic review of 15 investigations published between 2009 and 2018. An adaptation of the strategic management framework by Jauch and Glueck (1988) is developed to show the results.. Leaders, teachers, learners, families, and community members are identified as the key pillars upholding and maximizing mobile learning. The proposed framework is envisaged to serve as

[9] Moya, S., & Camacho, M. (2020). A Framework for mobile learning adoption and sustainable development. *Journal of Technology, Knowledge and Learning*. Under Review

a guide for the educational community in implementing sustainable mobile learning. The findings aim to be useful for academics and policy makers by providing insights for further research and successful mobile learning improvements.

The objective of the current study is to facilitate the sustainable adoption of mobile learning by developing a solid, simple, and effective framework oriented to the main agents of the educational community. This study focuses on the following research question: what are the main characteristics of a strategic framework for the adaption and sustained use of mobile learning?

The literature is replete with coverage of and perspectives on strategic management; substantial issues are essentially the same across authors defining strategic management: establishing an organization's mission and setting strategic goals, scanning the external and internal environments, evaluating strategic options, developing a plan, allocating resources and monitoring results. Glueck (1984) developed a framework of strategic management based on the general decision-making process. For the purpose of this article, we will refer to the Glueck framework published jointly with Lawrence Jauch in 1988, for its clarity, precision, and simplicity (Figure 67). Jauch and Glueck (1988) defined strategic management as a stream of decisions and actions that leads to the development of an effective strategy or strategies to help achieve corporate objectives.

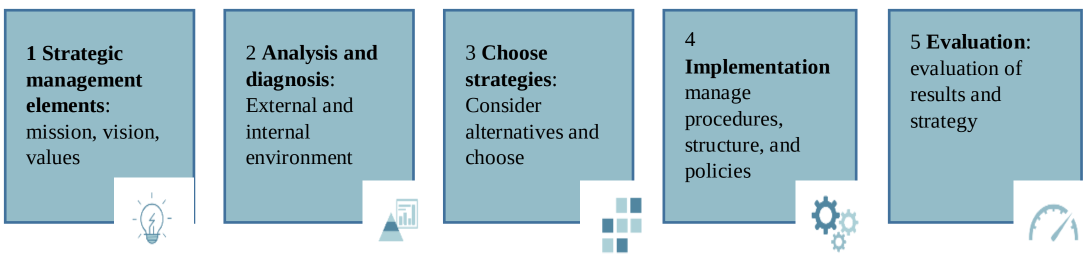


Figure 67. Strategic management framework (Jauch & Glueck, 1988)

(1) The first phase of the model refers to strategic management elements and is considered the core of strategic management. The management literature often defines the core elements as the vision, values, and mission of a firm (Gurley et al., 2015; Noble, 1999).

(2) The second phase of the model refers to analysing the context. The most significant management models regarding the scanning environment phase are strengths, weaknesses, opportunities, and threats (SWOT) analysis (Jauch & Glueck, 1988) and vulnerability, uncertainty, complexity, and ambiguity (VUCA) analysis (Bennett & Lemoine, 2014).

(3) The third phase of the model is to choose strategies, also called the strategy formulation or development phase, consisting of various alternatives and ensure that the appropriate strategy is chosen (Jauch & Glueck, 1988).

(4) The fourth phase of the model refers to implementation, and it covers the challenge of matching plans, policies, resources, structures, and administrative styles with the strategy (Jauch & Glueck, 1988; Noble, 1999)..

(5) The fifth and last phase of the model refers to evaluation.

In this context, the role of leaders is oriented towards guiding the process to match plans, policies, resources, structures, and administrative styles with the strategy (Jauch & Glueck, 1988; Noble, 1999).

6.1.2. Methodology

A systematic review (Hemingway & Brereton, 2009) approach was performed in this study to answer the research question directing this study, with the goal of providing an impartial synthesis, a summary and generalized relevant knowledge. To ensure that the review process was rigorous and valid, this study adapted the seven key steps identified in the practical guide to conducting and reporting systematic reviews created by Cook and West (2012), namely, (1) formulating the problem and defining the focus question, (2) searching for eligible studies, (3) deciding on the inclusion and exclusion criteria, (4) abstracting key information, and (5) analysing and synthesising the results.

Problem formulation

Following the above-described process, the first phase was to formulate the problem (step 1); i.e., a literature review has revealed a scarcity of effective and holistic frameworks for the adoption of mobile learning. In this context, the purpose of this research was to understand the crucial characteristics of a strategic framework for the adaption and sustained use of mobile learning.

Eligible studies search

For the second phase of the systematic review process, the following methodology was followed (step 2): the literature search was concept-centric (Okoli & Schabram, 2010) . For literature reviews conducted in relation to education, the Web of Science database has been recommended by several previous studies (e.g., Fu & Hwang, 2018). The expressions ("mobile learning" OR "ubiquitous learning" OR "blended learning" OR "M-learning" OR "B-learning" OR "mobile devices") AND ("framework" OR "model") were used.

Inclusion and exclusion criteria

The third phase of the systematic review was to decide on the inclusion and exclusion criteria (steps 3 and 4); in this research, we used the following inclusion criteria:

(1) The design of mobile learning frameworks or models was among the key variables of the study.
(2) The mobile learning was oriented towards educational purposes.
(3) The publication type was a journal article, book, or conference paper.
(4) Internationally oriented publication venues were used.

Papers published before 2008 were excluded since previous studies eminently referred to instructional design (Krull & Duart, 2017). Frameworks or models that focused exclusively on technical system design were also excluded. Grade levels and specific professional education programmes were not excluded since the literature review shows that, for the most part, mobile learning frameworks are not specified in that regard. Of the 15 studies finally included in the systematic review, 10 did not specify a grade, one was oriented to primary education, two were oriented to secondary education, and two were oriented to higher education. The research process initially yielded 454 publications. However, by applying the second-listed inclusion criteria, the research was filtered by educational domain, and the search was narrowed to 104 studies. After excluding the studies dated more than 10 years ago, the number of studies was reduced to 32. Based on the article titles and keywords, 5 articles were excluded because they did not focus on mobile learning frameworks. A total of 27 full-text articles were screened by the two authors, and based on the criteria, 15 articles were identified as eligible for the review and were thus comprehensively analysed by the authors (Table 61). Figure 68 shows the selection of the study process adapted from Yousra Banoor et al., (2019).

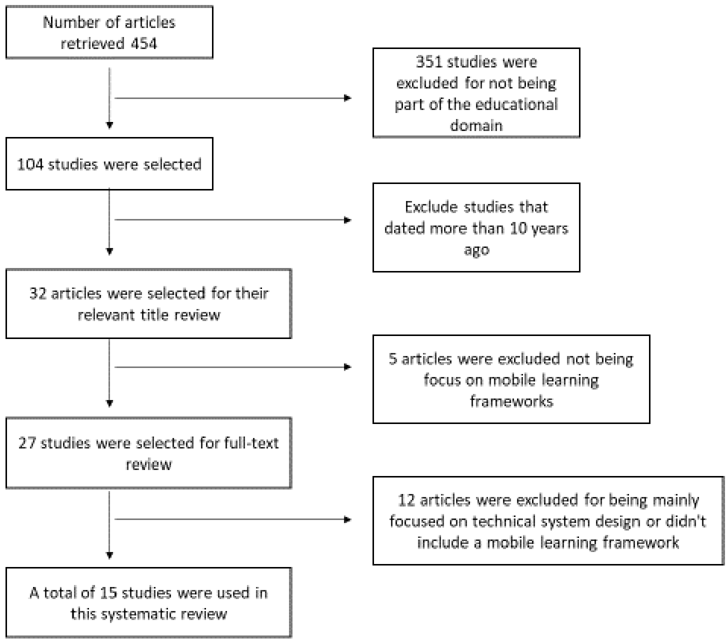


Figure 68. Selection of the study process (adapted from Yousra Banoor et al., 2019)

Table 61. Models and academic frameworks on mobile learning

STUDY	FRAMEWORK/MODEL
Ada (2018)	Mobile Learning Framework for Assessment Feedback
Al-Hunaiyyan et al. (2017)	Cognitive Knowledge-based Framework for M-Learning
Crompton (2017)	Mlearning integration framework
Hwang (2014)	Framework of a smart learning environment
Kearney et al. (2012)	Current framework comprising three distinctive characteristics of m-learning experiences, with sub-scales
Kennisnet (2011)	The four in balance monitor
Koole (2009)	The framework for the rational analysis of mobile education (FRAME)
Lim Abdullah et al. (2013)	Mlearning Scaffolding Five-stage Model
Liu et al. (2008)	Design framework for mobile learning

Ng and Nicholas (2013)	Person-centred sustainable model for mobile learning
Nordin et al. (2010)	A framework for mobile learning design requirements for lifelong learning
Park (2011)	Four types of mobile learning: a pedagogical framework
Peng et al. (2009)	The conceptual framework of ubiquitous knowledge construction
Rikala (2015)	Mobile learning framework
Veerabhadram et al. (2012)	The design and the role of different academic tools

Abstracting information

The fourth phase in the adapted systematic review process involved extracting key information (step 5) (Cook & West, 2012). The data extraction was carried out based on the different elements of the strategic framework by Jauch and Glueck (1988), with the following parameters: code, title, year, authors, citations, journal, name of the framework, grade level, vision/mission, environment analysis, strategies, implementation, evaluation, pedagogical methods, and stakeholders. The extracted information was synthesized and structured in a metadata table to facilitate analysis. Appendix 1 contains the link to access the metadata table- Then, a thematic synthesis (Thomas et al., 2012) was conducted to analyse the principal elements.

6.1.3. Results

Key information of the studies

The fifth and final phase in the adapted systematic review process involve analysing (step 6) and synthesizing (step 7) the results (Cook & West, 2012). Mobile learning models and frameworks integrate multiple and complex interrelated aspects and elements. To manage this complexity and facilitate organization, the strategic framework described above was adapted and used as a foundation. Figure 69 describes the five phases of Jauch and Glueck' s framework adapted for mobile learning adoption.

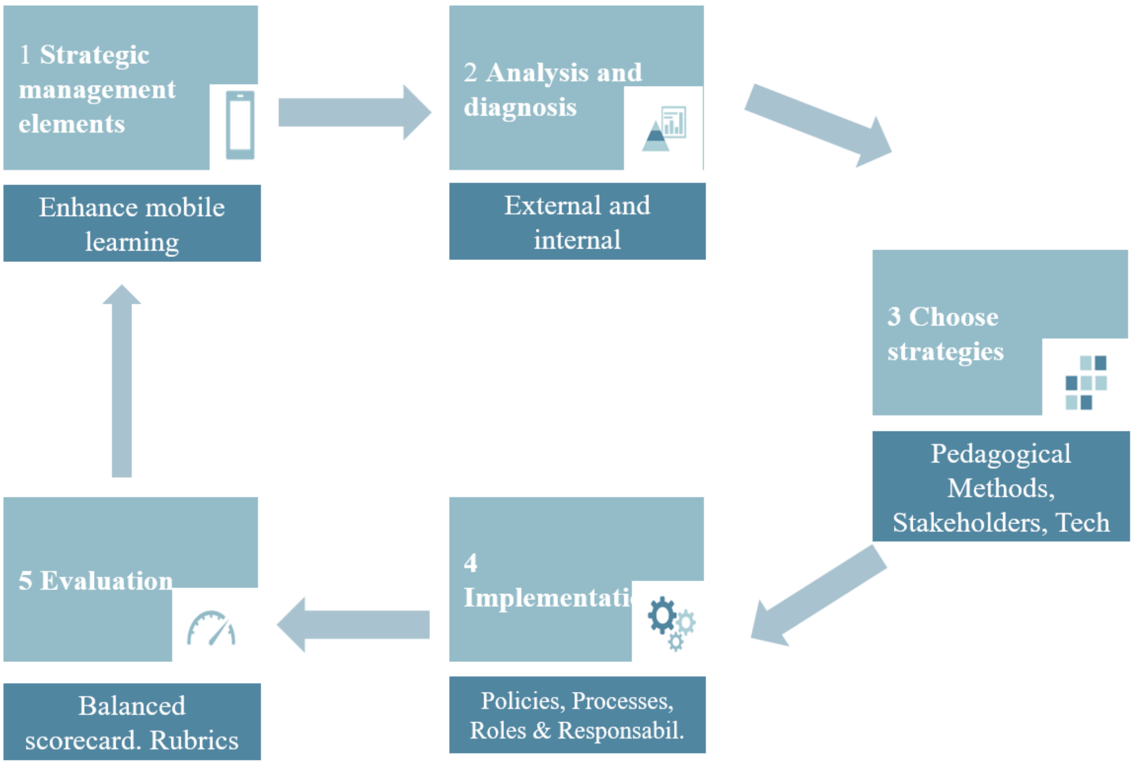


Figure 69. Strategic management framework(Jauch & Glueck, 1988) adapted for mobile learning adoption

Strategic management elements

Multiple studies have defined mission, vision, and values as the core management elements (Gurley et al., 2015; Noble, 1999). Six out of the 15 studies researched here referred to these elements using different approaches. Pen and Su (2009) and Kennisnet (2013) referred specifically to vision as ubiquitous knowledge construction. Learning objectives, learning outcomes and learning progress were used in several frameworks (Ada, 2018; Lim Abdullah et al., 2013; Nordin et al., 2010; Rikala, 2015).

Although strategic elements were not specifically shown in their models or frameworks, most of the studies included references to their purpose, mission and vision in the research question or in the purpose of the study (Ada, 2018; Crompton, 2017; Kearney et al., 2012; Lim Abdullah et al., 2013; H. Liu et al., 2008; Park, 2011; Peng et al., 2009). Synthesising the above references according to their mission and vision, the following understanding of the overall mission and vision was highlighted: enhancing mobile learning was the mission, while gaining skills for the 21st century was the vision. Values were referred to in five studies (Ada, 2018; Kearney et al., 2012; Ng & Nicholas, 2013; Nordin et al., 2010; Rikala, 2015). Among all the studies, the following were highlighted as crucial values for developing a solid mobile learning framework: collaboration, courage, communication, creativity, trust, and culture. These values comprise the frame of reference that always guides decision making. To provide further details about the framework, a strategy tool has been designed. The top of Fig. 5 shows the first phase of the framework for the sustainable adoption and development of mobile learning.

Analysis and diagnosis

The second phase of Jauch and Glueck's framework focuses on the external environment and internal analysis and diagnosis. A total of nine studies included contextual references. In their framework, Nodin et al. (2010), included an external environmental analysis and referred to generic mobile environment issues and internal analysis as mobile learning contexts. Most studies combined both external and internal analyses and referred to context. Rikala (2015) split context into three areas: curriculum, ICT strategies, and teacher competencies. Other approaches to context are content and knowledge construction (Lim Abdullah et al., 2013); contextualization (Kearney et al., 2012); information context (Koole, 2009); learning environment (Hwang, 2014); expertise and infrastructure; requirement and constraints analysis (H. Liu et al., 2008); and suppliers, software developers, government bodies, the media, and researchers (Ng & Nicholas, 2013). The right side of Fig. 5 shows the second phase of the framework. An external environmental analysis indicates the global levels of the development of resources (human, pedagogical and technological) and an internal analysis refers to the internal availability of resources.

Strategic Choices

The third phase of Jauch and Glueck's model examines strategic choices and formulations. All the models and frameworks analysed used a combination of different pedagogical and technological strategies as the key strategies of their mobile learning frameworks or models. Table 62 depicts the categorization into one of these two strategic categories of each framework or model.

Table 62. Pedagogical and technological strategies in mobile learning frameworks

STUDY	PEDAGOGICAL	TECHNOLOGICAL
Park (2011)	Transactional distance, individualized, socialized	
Peng, Su, Chou, & Tsai (2009)	Constructivism and lifelong learning	Ubiquitous computing
Nordin et al. (2010)	Behaviourism, cognitivism, constructionism, and mobile learning	Technical resources, facilities, support services, and spatial-temporal elements
Rikala (2015)	Pedagogical practices	Device aspect
Lim Abdullah et al. (2013)	Motivation, socialization, information exchange, Knowledge construction and development	Technical support
(Kearney et al., 2012)	Collaboration, personalization, authenticity	Use of time-space
Koole (2009)	Social aspect	Device aspect
Hwang (2014)	Constructivism, motivational theory, the technology acceptance model, cognitive load theory and	Tools, profiles, materials, test bank, portfolios
Kennisnet (2011)	Expertise, content, and applications	Infrastructure
Veerabhadram, Beer, & Conradie (2012)	Communication, mobile application, face to face	Mobile device
Liu *et al*. (2008)	Activity design	Support services devices
Ng & Nicholas (2013)	Pedagogy, formal and informal learning	Mobile device, peripherals
Al-Hunaiyyan, Bimba, Idris & Al-Sharhan (2017)	Meta-cognition	Device
Bikanga Ada (2018)	Pedagogy	ICT Infrastructure
Crompton (2017)	Methods	Resources

Pedagogical strategies include theories of learning (constructivism, behaviourism and conceptualism, among others); general approaches, theories, and tools (such as mobile application, multimedia design theory, content applications, activity design) and pedagogical approaches (collaboration, personalization, authenticity). Technological strategies refer to resource characteristics (device, tools, materials, banks of digital resources) and technological support.

Implementation

The fourth phase of Jauch and Glueck's model focuses on implementation. Ten of the frameworks and models analysed were mainly focused on the learner (Al-Hunaiyyan et al., 2017; Crompton, 2017; Hwang, 2014; Kearney et al., 2012; Koole, 2009; Lim Abdullah et al., 2013; Nordin et al., 2010; Park, 2011; Peng et al., 2009; Rikala, 2015). Three other frameworks referred to other stakeholders as follows:

(1) The learner, organization, project team, and community (Liu et al., 2008).

(2) Teachers, school managers, school administrators, parents, support staff and learners (Kearney et al., 2012); and

(3) Technicians, students, teachers, parents, leaders and managers, and the wider community (Ng & Nicholas, 2013).

Stakeholders are considered the key pillars for mobile learning adoption, not only during the implementation phase but also throughout the process. To present the framework, the key stakeholders were identified as leaders, teachers, learners, families, and community members. These key pillars have been considered independently; however, they constantly interact with each other. The roles and responsibilities of each of the pillars depend on their mobile learning impact. Islam and Grönlund (2016) conducted a review of 145 papers from 2000 to 2012 to accumulate evidence of the uses and impacts of computer learning. Most of the literature reviewed by the authors was focused on the articles by Fisher (2005-2010), Holcomb (2003-2008) and Penuel (2001-2005). Table 63 shows the results that Islam and Grönlund adapted for each of the framework pillars.

Table 63. Mobile learning impact on stakeholders. Adaptation from Islam and Grönlund (2016)

KEY PILLAR	MOBILE LEARNING IMPACT
Leaders	Access to in the class content
	Improve multilevel communication
	Standardization to ensure quality levels
	Team management motivation
	Online Feedback
Teachers	Classroom dynamism
	Collaboration
	Computing skills
	Constructivist and flexible teaching
	Discipline behaviour problems
	Teacher-student interaction improve
	Professional development
	Overdependency on information (negative)
Learners	Cognitive skills
	Computing skills

	Engagement and motivation
	Help special needs students
	Homework
	Quality of work and achievements
	Research and writing skills
	Self-direct, independent learning
	Insignificant academic achievement (negative)
	Physiological as well as physical strains (negative)
	Additional Distraction (negative)
Family	Increases parental involvement in school and technological literacy
	Assist Homework
Community	Industry: Increases innovations and sales; reduce prices.
	Reduce socio-educational inequalities

School leaders are responsible for constantly guiding the school in response to new cultural challenges, environmental demands, resources, and expectations. Ng and Nicholas (2013) outlined that leadership and management roles are focused on deciding policies, managing finances, and providing leadership support. Fig. 5 shows the crucial roles for leaders, i.e., lead changes and align, develop, and coordinate resources.

The main role for teachers has switched from class leader to facilitator (Islam & Grönlund, 2016; Smart et al., 2012). Teachers are responsible for both developing learning designs and their own professional development. Learning design is oriented towards developing pedagogical methodologies that optimize resources (Dalziel et al., 2016). As mentioned in the literature review, some of the educational strategies and models such as SMAR, TPACK, BYOD and flipped classroom are adaptable to mobile learning (Koole, 2009; Ng & Nicholas, 2013; Rikala, 2014). . Finally, as mentioned previously, teachers are required to assume leadership roles (Darling et al., 1995; Fullan, 1996; Spillane & Healey, 2010). Fig. 5 reflects the key responsibilities of teachers, i.e., develop and facilitate both learning designs and professional development.

The learner's role has moved to the centre of the learning process (Hwang, 2014; Ng & Nicholas, 2013; Smart et al., 2012; Veerabhadram et al., 2012). Thus, learners must broaden their responsibilities to include a proactive contribution to the mobile learning process. Student-centred designs are rooted in constructivist and constructionist pedagogical theories and seek to develop learner autonomy and independence (Hannafin et al., 2014; Hwang, 2014). Fig. 5 outlines the learner-centred role and responsibilities, i.e., maintain a central role and learn from multiple perspectives, environments, and resources.

A vast body of literature highlights that the increasing involvement of families in learning processes has positive effects (Boonk et al., 2018; Epstein, 2013; K. Williams et al., 2017). However, only one of the frameworks analysed referred to parents. In their framework, Ng and Nicholas (2013) grouped parent responsibilities according to their relationship with other stakeholders: communicate and provide support and trust to students; negotiate costs with, consult with, inform and provide feedback to leaders; and consult and provide feedback to teachers. Epstein (2013) identified six types of involvement: parenting, communicating, volunteering, learning at home, decision making and collaborating with the community. Fig. 5 summarizes the fundamental responsibilities of families, i.e., facilitate learning experiences, environments, and resources.

Isler's framework for the sustainability of ICT in education, cited by Ng and Nicholas (2013), highlighted the role of the community as the potential link to economic, social, and political aspects of sustainability. The community pillar is not limited to educational institutions and policymakers but also includes a wide range of organizations, such as technology developers, researchers, and political leaders. Consequently, community members' contribution to the framework covers a wide range of endeavours, including developing new learning environments and resources to ensure the sustainability of the framework. According to Ng and Nicholas (2013), this sustainability has five main dimensions: economic, social, technological, political, and pedagogical. The fourth and fifth rows of Fig. 5 show the responsibilities of pillars and community members, i.e., develop learning strategies, environments, and resources.

Evaluation

The fifth and last phase of Jauch and Glueck's model is the evaluation phase. Evaluation is a crucial phase in strategic planning since it allows evaluators to readjust and focus on the process (M. E. Porter, 1996). Four studies included evaluation or assessment in their frameworks (Hwang, 2014; Ng & Nicholas, 2013; Rikala, 2015; Veerabhadram et al., 2012). All the frameworks considered the evaluation part of the learning design or pedagogical activity oriented towards monitoring and evaluating learning progress and outcomes.

Designing a framework for mobile learning adoption and sustainable development

CHAPTER 7

DISCUSSION, AND CONCLUSION

This study is contextualized in an environment where digitalization is a global priority, mobile penetration levels are close to 100% and its functionality offers unlimited possibilities to improve learning processes. Despite this, there is a gap between the availability of technology and use in the classroom, and even when it happens, it often does not optimize results mainly because its adoption neglects fundamental elements of the process (Keengwe et al., 2008; Kopcha, 2012; Miltenoff et al., 2013; Motiwalla, 2007; Nikolopoulou & Gialamas, 2016; Park, 2011; Peng et al., 2009). Along with the lack of effectiveness in the adoption of mobile learning, there is consensus on the lack of a coherent and sustainable model that offers a holistic approach, orchestrating all the elements and oriented to practice (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). In this context, the main objective of this research is to enhance the adoption and sustained use of mobile learning by developing a strategic framework. In this chapter, the results of the research are summarized in response to the research questions; The results are discussed identifying the research contributions, offering suggestions for future research and specifying the limitations of the study and finally the conclusions are presented.

7.1. Findings of the study

7.1.1. Current situation of research in mobile learning

The first research question guiding this research is: what is the current state of mobile learning research? The approach to answer this question was included in study 1 entitled "A taxonomy of mobile learning based on a systematic review" included in Chapter 3. The main methodology used was an exhaustive review of the literature as well as a systematic review of 25 studies.

The study reveals that in the analysis of mobile learning, there is a vast literature, whose results are significantly consistent in their main aspects (Hwang & Tsai, 2011; Krull & Duart, 2017; Wu et al., 2012). The findings revealed that the number of articles published has significantly increased over the last ten years. The top 15 journals account for 47.2% of mobile learning literature. Both the number of articles and the number of authors' citations are high. Asia is the continent with more contributions to mobile learning research, and Taiwan is the most dominant country. Most studies feature positive outcomes, consistent with previous studies (Chee et al., 2017; Crompton & Burke, 2018; Hwang, 2014; Islam & Grönlund, 2016; H. Liu et al., 2008; Mahdi, 2018; Moya & Camacho, 2020a; Núñez et al., 2015; Pimmer et al., 2016; Y. T. Sung et al., 2016; Virtanen et al., 2018; Wu et al., 2012; Zheng et al., 2018) . The results also showed that overall, students are engaged and like using handheld devices (Pimmer, 2016). However, there is a need to develop efficient procedures and tools to ensure the accurate outcomes' measurement (Ada, 2018). The focus of the studies has been on learning effectiveness. Most of the target sample are students from higher education; there is a significant need for conducting primary and secondary education research. The environment is a hybrid one, with a tendency to being informal. In relation to the learning domain, the spectrum is too wide to make conclusions. Similarly, the variety of mobile learning devices are constantly growing consequently, research findings are likely to change with ongoing technological development. In addition, Bring Your Own Device (BYOD) strategies and multiple device usage are widely integrated into educational environments (Alwan et al., 2017; Armando et al., 2014; Traxler, 2016). New tendencies showed the relevance of mobile learning software and new technologies such as GPS (Global Positioning System), RFID (Radio-Frequency Identification) and QR (Quick Response) allowing real world contextualization (Hwang, 2014; McDonald et al., 2018). There is a clear trend to use mixed methodologies and a wide variety of data collection methodologies. The results also evidenced and recognized the lack of current research focused on the development of theoretical frameworks and models for the sustainable adoption of mobile learning (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 findings also suggest that there is a need for standardization and categorization to build solid foundations for mobile learning research.

One of the main contributions of the study 1 referred to status of mobile learning research, has been the identification of the need to standardize and categorize the main aspects of mobile learning and the proposal of a taxonomy. This study provides a conceptual model to categorize and orchestrate the characteristics that define the current state of research in mobile learning. This model provides a holistic and coherent vision of current mobile learning research . The results are consistent with previous studies. The additional contribution is the three-year extension with respect to the last study analyzed and the breadth of the study that includes a total of 1828 original academic publications. This new taxonomy contributes to a deeper understanding of mobile learning: this has implications for academics. This taxonomy can guide future research efforts, is expected to optimize the research process in the field of mobile learning and can contribute to moving towards sustainable and effective adoption models. Having implications for educational stakeholders interested in mobile learning, the taxonomy proposed provides a quick and comprehensive overview. Combining the 25 studies included in the systematic review, 99 categories were analysed and grouped into 13 categories. Those categories were assembled and organized under five higher dimensions: bibliometrics, research purposes, demographics and context, methodology, and outcomes. Figure 70 shows the conceptual model.

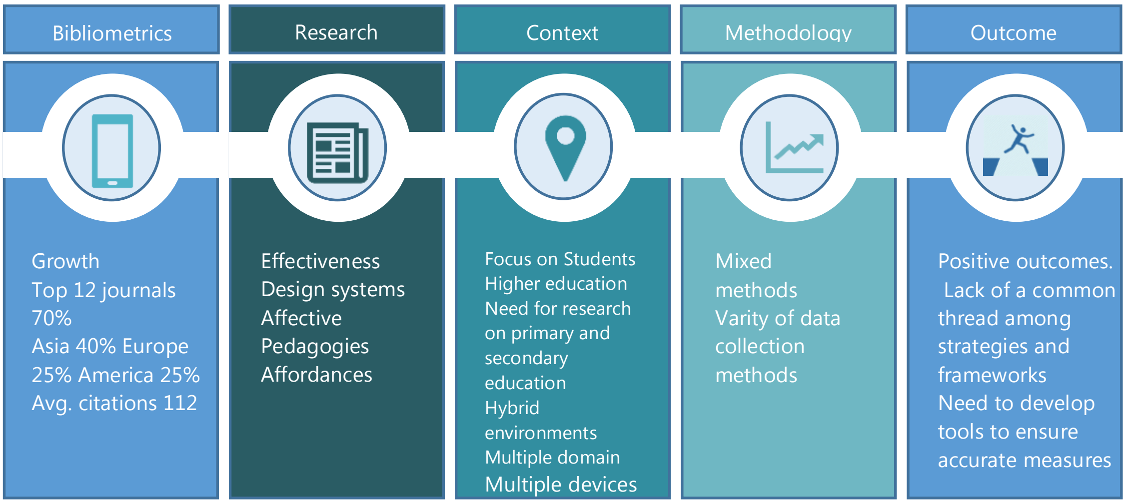


Figure 70. A conceptual model for mobile learning research

7.1.2. Main Characteristics and functionalities of mobile learning

The second research question is what are the main characteristics of current mobile learning frameworks?. The second study included in this thesis: "characteristics, functionalities and benefits of mobile learning: systematic review of the literature" included in Chapter 3 aims to answer this research question. This study is based on the systematic review of 41 studies that contain definitions of mobile learning. The concept of mobile learning has evolved over the last few years from an eminently technological vision, towards a pedagogical position and currently a trend is confirmed where social attributes are the most prominent. These results are consistent with previous findings (Grant, 2019; Koole, 2009; Sharples & Pea, 2014; Trifonova, 2003). These three axes position the main characteristics and functionalities of mobile learning: accessibility and immediacy are technological aspects that mobile learning provides, ubiquity allows expanding the pedagogical dimension of learning, and interactivity enhances the social dimension. These characteristics provide the following functionalities: autonomy, flexibility, permanence, instantaneity, contextualization, Situationality, informality, collaboration and cooperation, personalization, socialization, and feedback. The exceptional functionalities of mobile learning contribute to the development of different pedagogical principles of learning. This study has been based on the 7 cross-cutting principles that guide the development of learning environments in the 21st century published by the OECD and based on both cognitive, emotional and biological perspectives (Dumont et al., 2010): learners at the centre; social nature of learning; emotions are integral to learning; recognising individual differences; stretching the results; assessment for learning and building horizontal connections.

The greatest contribution of the second study is the creation of a model where the main characteristics, functionalities and pedagogical benefits of mobile learning are identified, as well as its main relational links. The main contribution, which makes it different from previous work in the literature, is the concordance and coherence between characteristics, functionalities and pedagogical benefits synthesized in a model. The relationship between characteristics, functionalities and learning principles is not linear, different characteristics contribute to provide different functionalities and different functionalities enhance different principles in a matrix way. It is important to highlight that the effort to categorize responds to the need to facilitate understanding and analysis and in any case recognizes and defends the multiple interrelationship between any of the categories, functionalities and learning principles, as well as the dependence of contextualization for their interpretation. To provide a simplified model based on the systematic review carried out, Figure 71 summarizes the fundamental elements and relationships. This model can guide educational centres, instructional designers, educational developers, and authorities in the organized and effective adoption of mobile learning. The identification of characteristics and functionalities is fundamental to elaborate learning designs for sustainable mobile learning (Grant, 2019; A. Herrington et al., 2009).

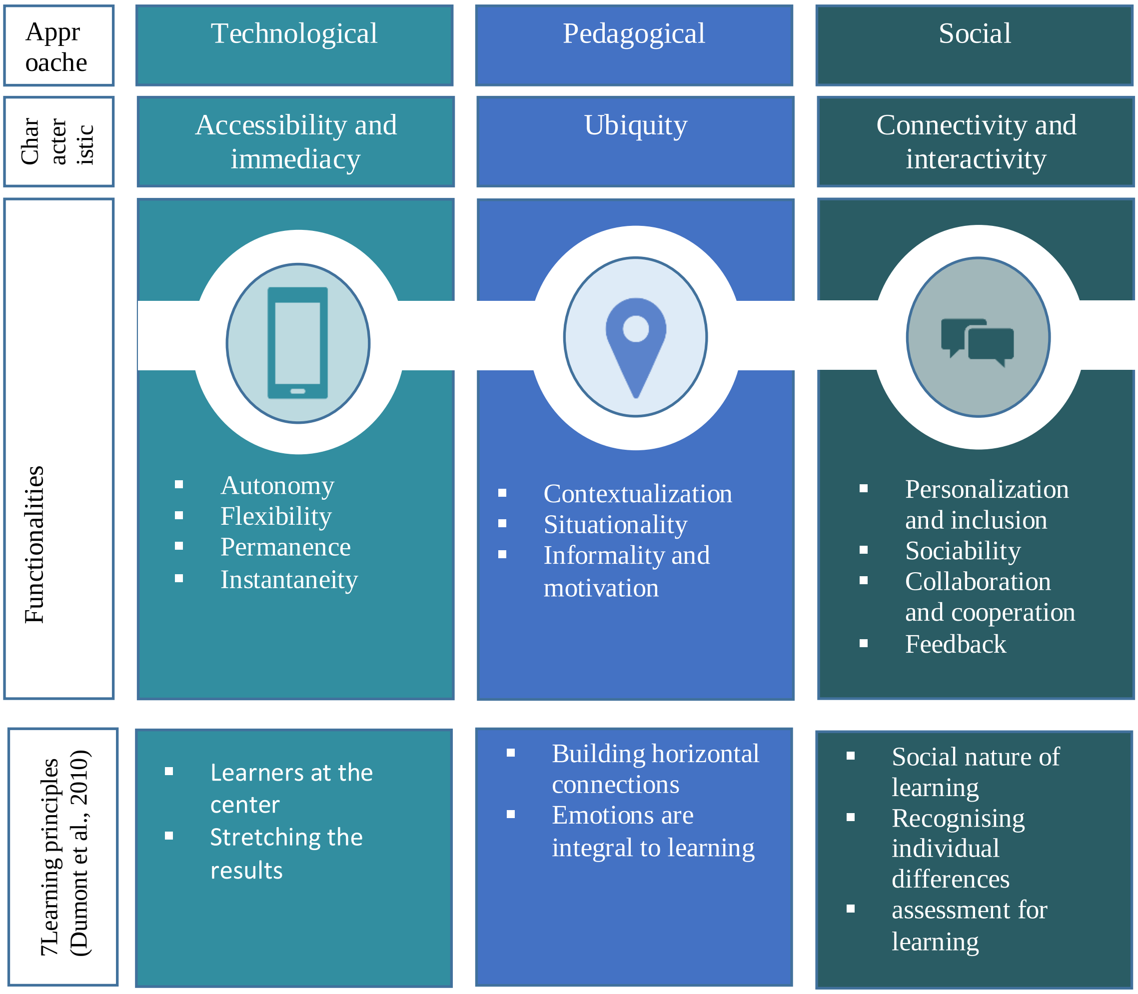


Figure 71. Characteristics, functionalities, and pedagogical benefits of mobile learning

7.1.3. Mobile learning design principles

The article "Design Principles of Mobile Learning Frameworks" included in Chapter 4, provides answers to the third research question of this thesis: RQ3. What are the main design principles used for the development of frameworks for the adoption and sustainable use of mobile learning? The study is based on the systematic review of the literature of 20 studies that include mobile learning frameworks. 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 significantly 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 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. The study identified 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; 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.

The greatest contribution of this study is the presentation of the fundamental design principles for the development of a mobile learning framework:

(1) 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 centre 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).

(2) *Include the evaluation* of the models to be able to readjust and constantly evolve them is the second design principle. Only one model explicitly refers to evaluation as part of the Pedagogical dimension (Ada, 2018).

(3) 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 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).

(4) 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.

(5) 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.

(6) The sixth design principle for the adoption of mobile learning is to *set clear objectives aligned with the mission, vision, and values* of the institution. 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. 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).

(7) Follow an *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 that includes lawmakers, instructional designers, system developers, among others (Ng & Nicholas, 2013).

7.1.4. Critical success factors affecting mobile learning

Three studies have been conducted to answer the fourth research question of this thesis, RQ4. What are the critical success factors for the adoption and sustainable use of mobile learning in education? Study 5: "Identifying the key success factors for the adoption of mobile learning", it consists of a qualitative investigation consisting of an expert trial, where 7 experts participated; study 6: " What factors matter most for mobile learning adoption?" is based on a review of the literature to identify and code the factors that affect the adoption of the literature; and study 8: " Factors affecting the adoption of mobile learning in Catalonia" based on 147 participants in a questionnaire .

This part of the research is included in the third phase of the design-based research approach (Chapter 5). This phase consists of three iterative cycles with the objective of testing, evaluating, and refining in a practical way the prototype presented in the previous phase (Reeves et al., 2005). Iterations are a fundamental part of the DBR process since they refine and model the initial design, multiple iterations guarantee a more precise fit of the initial prototype (Stemberg & Cencic, 2014). In this part, the initial mobile learning framework is evaluated through three iterations

There are multiple studies analyzing the factors that affect the integration of technologies in education. A total of 361 different factors were identified in our analysis. However, there are fewer studies aimed at grouping and classifying these factors (Cochrane & Bateman, 2010; Teoh, 2011). Factors affecting mobile learning adoption were initially grouped into two major categories based on a dimension that mediates the tangibility of the factors: hard and soft. The hard category refers to those factors that impact the learning process in a way that the institutions could manage and measure in a reasonable way (Dewar et al., 2011; Guohui & Eppler, 2008; Higgins, 2005; Humaidi et al., 2010; Peters & Waterman, 2006). This group includes three categories of factors:

(1) *Technological resources* that includes factors such as technological infrastructure, navigation, internet connection, mobile tools, level of integration, technical support, student-device ratio, or hardware, some authors referred to this category as affordability, mobile device, ICT, infrastructure, physical and technological infrastructures, technological aspects or technological factors (Aguti et al., 2014; Al-Sharhan et al., 2010; Alrasheedi & Capretz, 2015; Bower et al., 2015; Cochrane &

Bateman, 2010; Goyal et al., 2010; Kukulska-Hulme, 2008; Mahdi, 2018; Rikala, 2015; Sabah, 2016; Tay et al., 2013; Teoh, 2011).

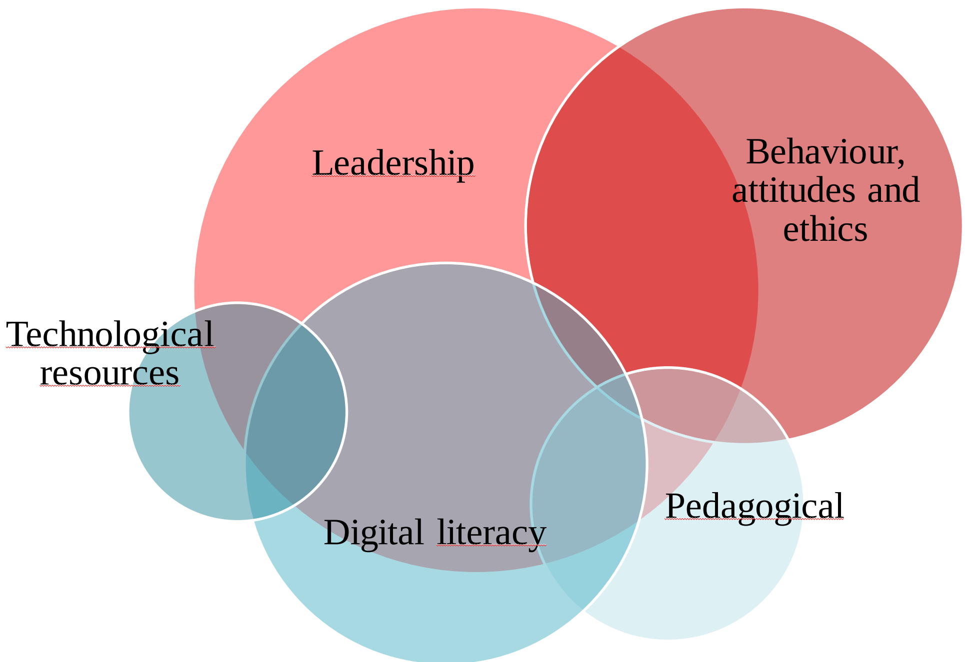
(2) *Pedagogical factors*: the second category encompasses pedagogical factors, such as classroom integration, adaptability of the course, assessment, availability of content and software, critical thinking, thinking development, time management, recognition of informal learning, defining target learner groups for m-Learning, teaching preparation, curriculum; design approach, gamification, virtual environments and customization(Aguti et al., 2014; Al-Sharhan et al., 2010; Alrasheedi & Capretz, 2015; Bower et al., 2015; Cochrane & Bateman, 2010; Ekberg & Gao, 2018; Goyal et al., 2010; Kukulska-Hulme, 2008; Mahdi, 2018; Rikala, 2015; Sabah, 2016; Stacey & Gerbic, 2008; Tay et al., 2013; Teoh, 2011).

(3) *Digital literacy*: a third category included within the group of hard factors refers to the educational community's mobile learning skills or digital literacy. To this category belong the following factors: teachers' digital knowledge, training, students' knowledge, teachers' and students' digital competency, and teachers' practices and digital assessment knowledge (Alrasheedi & Capretz, 2015; Cochrane & Bateman, 2010; Ekberg & Gao, 2018; Esteve, 2015; Lu & Viehland, 2008; Mercader, 2018; Rikala, 2015; Sabah, 2016; Stacey & Gerbic, 2008; Tay et al., 2013; Yadegaridehkordi et al., 2013; Yeap et al., 2016). On the other hand, the soft categories are those that mainly affect the soul and the people and the institutions (Dewar et al., 2011; Guohui & Eppler, 2008; Higgins, 2005; Humaidi et al., 2010; Peters & Waterman, 2006).. Two categories can be derived from this group: personal character and ethics and leadership.

(4) *Personal characteristics, features, and ethics* integrates human-related factors, with a focus on individual personal character and ethics. Often labelled as soft or human factors, this category includes behaviours and attitudes, teachers' attitudes, motivation and resistance to change (Ekberg & Gao, 2018; Hamidi & Chavoshi, 2018; Hu et al., 2017; Keengwe, 2007; Kukulska-Hulme, 2008; Y. Liu et al., 2009; Mercader, 2018; Spector, 2013; Yeap et al., 2016). This category also includes computer ethics (S. Jones, 2017) and demographic factors (Tan et al., 2012) .

(5) *Leadership*: the fifth category integrates human-related factors, with affecting organizations and groups and highlighting leadership among the most cited. The most cited factor included in this category is communication, collaboration, and cooperation (Alrasheedi & Capretz, 2015; Goyal et al., 2010; Hamidi & Chavoshi, 2018; Hu et al., 2017; Kukulska-Hulme, 2008; López-Hernández & Silva-Pérez, 2016; Mercader, 2018; Rikala, 2015; Stacey & Gerbic, 2008; Tay et al., 2013).

The findings derived from the expert judgment confirm the proposed categorization and offer a hierarchy of the importance of both the previously described categories and 50 specific factors that were included during the expert judgment session. The results reveal that the soft categories are more relevant when adopting mobile learning than hard ones. Leadership has been identified prominently as the crucial category. Within the hard categories, pedagogy has stood out in digital literacy, while the technological resources category has had the least relevant assessment. Among the different groups of participants, namely, inspectors, school leaders and university experts, there have been no significant discrepancies in relation to the most and least relevant categories. The Venn diagram illustrated in Figure 72 shows the classification of the above critical success factors affecting mobile learning according to the criteria of the panel of experts. The size of the elements of the Venn diagram represents the prioritization of the different categories represented in Figure 72. The colour scheme distinguishes the soft and hard categories. The categories in red



are soft, and the categories in blue are hard.

Figure 72. Classification of key factors affecting mobile learning adoption in Catalonia

The second iteration to refine the mobile learning framework consisted of a study on the factors that affect the adoption of mobile learning in Catalonia, through a questionnaire that was answered by 147 teachers. Data analysis was carried out using the PSPP program. The type of tests carried out are descriptive (means and deviations), comparison (Chi2 test), differences (ANOVA test) and correlation (Pearson's correlation).

The first finding of this study was the confirmation of the categorization of factors that affect mobile learning that had been identified in the first iteration. The categorization of the factors for the adoption and sustainable use of mobile learning consists of five categories based on their characteristics and classifications identified in the theoretical framework: technological, related to digital literacy, pedagogical, related to behaviour, attitude and ethics and finally , related to leadership as shown in table 64.

Table 64. Frequencies of the degree of agreement of the categories of factors that affect the adoption of mobile learning

	STRONGLY AGREE	AGREE	NEUTRAL	DISAGREE	STRONGLY DISAGREE
Technological resources	20%	36%	31%	8%	5%
Digital literacy	26%	35%	29%	6%	4%
Pedagogical	46%	26%	19%	5%	4%
Behaviour, attitudes, and ethics	50%	26%	17%	3%	4%
Leadership	51%	29%	13%	5%	3%

Three categories have been identified by the sample as quite relevant: digital literacy, behaviour, attitude and ethics, and pedagogical aspects, in this order of relevance. The findings show a significant relationship based on age to assess the category of pedagogical aspects, being positive, the older it is valued. A significant correlation has also been detected in relation to the years of experience and the category of digital literacy, the more years of experience, the more it is valued. Finally, no significant relationship with gender has been detected. As evidenced by the significance of the ch2 test in the sociodemographic variables shown in table 65.

Table 65. Significance of the Chi2 test in sociodemographic variables

	GENDER	AGE	EDUCATIONAL LEVEL	EXPIRIENCE	TYPE OF CENTER
Digital literacy	0.57	0.2	0.16	0.11	0.5
Pedagogical	0.21	0.52	0.25	0.59	0.86
Behaviour, attitudes, and ethics	0.37	0.83	0.37	0.12	0.17
Leadership	0.21	0.47	0.42	0.37	0.42
Digital literacy	0.20	0.63	0.59	0.12	0.4

7.1.5. Indicators and characteristics to develop a tool to evaluate and monitor the adoption of mobile learning

This section summarizes the findings revealed with the research that answers the fifth research question RQ5. What are the indicators and characteristics to develop a tool to evaluate and monitor the adoption of mobile learning? This part of the research is included in the third phase of the design-based research approach (Chapter 5). It is the third of the three iterations (Stemberg & Cencic, 2014) that this research includes to refine and test the proposed prototype of the mobile learning framework. This iteration aims to refine the framework with the identification of the main indicators in order to evaluate and adjust the process. The results are collected in the article entitled "Dashboard for monitoring the adoption of mobile learning in education" identified as study 8 in this thesis, based in a systematic review of 20 studies.

The findings of this study begin with the identification of the characteristics of mobile learning, from which the indicators are derived for their evaluation and are subsequently collected in a scorecard. The main characteristics that dimension the main models for the adoption of mobile learning that have been identified in this study are five: pedagogical (Burris, 2017; Hsu & Ching, 2015; Khaddage et al., 2016; Traxler, 2010; Wong & Looi, 2011); technological (Ada, 2018; Brummelhuis & van Amerongen, 2011; Buckley et al., 2009; Churchill et al., 2016; Crompton, 2017; Hwang, 2014; Koole, 2009; Lim Abdullah et al., 2013; Mishra & Koehler, 2006; Ng & Nicholas, 2013; Rikala, 2015; Veerabhadram et al., 2012); contextual-spatial (Crompton, 2017; Kearney et al., 2012; Khalid et al., 2015; c et al., 2008; Nordin et al., 2010; Peng et al., 2009); transactional (Ada, 2018; Crompton, 2017; Hwang, 2014; Lim Abdullah et al., 2013; Liu et al., 2008; Motiwalla, 2007; Park, 2011;

Sharples & Vavoula, 2009; Veerabhadram et al., 2012); and leadership (Brummelhuis & van Amerongen, 2011; Khaddage et al., 2015; Ng & Nicholas, 2013; Peng et al., 2009).

The following indicators have been identified to evaluate the quality of the adoption of mobile learning in its pedagogical dimension: adaptation of mobile learning materials (Brummelhuis & van Amerongen, 2011; Mishra & Koehler, 2006); specific adaptation assessment of mobile learning; (Ada, 2018; Churchill et al., 2016; Hwang & Wu, 2014; Khalid et al., 2015); specific training mobile learning (Ada, 2018; Lim Abdullah et al., 2013); planning mobile learning activities in classrooms; (Ada, 2018; Churchill et al., 2016; Koole, 2009; Mishra & Koehler, 2006; Ng & Nicholas, 2013; Nordin et al., 2010; Peng et al., 2009; Puentedura, 2009; Rikala, 2015; Sharples & Vavoula, 2009; Veerabhadram et al., 2012); teacher / student participation ratio (Crompton, 2017; Rikala, 2015); specific pedagogical support for mobile learning (Churchill et al., 2016; Crompton, 2017; Hwang, 2014).

In relation to the technological dimension, the following indicators have been identified: reliability of connections (Crompton, 2017; Hwang, 2014; H. Liu et al., 2008); mobile device ratio including BYOD (Ada, 2018; Brummelhuis & van Amerongen, 2011; Churchill et al., 2016; Khalid et al., 2015; Koole, 2009; Mishra & Koehler, 2006; Nordin et al., 2010; Peng et al., 2009; Puentedura, 2009; Rikala, 2015; Sharples & Vavoula, 2009; Veerabhadram et al., 2012); technological specific support for mobile learning (Lim Abdullah et al., 2013; Ng & Nicholas, 2013).

The indicators that assess the contextual and spatial dimension identified are: formal and informal learning (Y. Liu et al., 2009); contextualization of authentic and situated learning (Kearney et al., 2012; Khalid et al., 2015; Nordin et al., 2010; Peng et al., 2009; Rikala, 2015).

The transactional dimension in the adoption of mobile learning can be evaluated with the following indicators: social learning through devices, (e.g. virtual debates); (Ada, 2018; Crompton, 2017; Kearney et al., 2012; Koole, 2009; Lim Abdullah et al., 2013; Motiwalla, 2007; Ng & Nicholas, 2013; Park, 2011; Rikala, 2015; Sharples & Vavoula, 2009; Veerabhadram et al., 2012); personalization of learning (Ada, 2018; Hwang, 2014; Kearney et al., 2012; Koole, 2009; H. Liu et al., 2008; Motiwalla, 2007; Veerabhadram et al., 2012); cooperative knowledge construction (Churchill et al., 2016; Motiwalla, 2007).

Finally, for the evaluation of the strategic quality of the adoption of mobile learning, the following indicators have been identified: strategic planning of the adoption of mobile learning (Brummelhuis & van Amerongen, 2011; Khalid et al., 2015; Ng & Nicholas, 2013; Peng et al., 2009); define policies and processes and provide support from the management team (Ng & Nicholas, 2013).

The main contribution of this study is the design of a dashboard prototype to evaluate the quality and adjust the adoption of mobile learning. It is based on the main dimensions of mobile learning adoption and the main indicators that feed them. This prototype that will help both educational centres, researchers, politicians, and agents of the educational community in general, to evaluate the quality of the implementation of learning with mobile devices to adjust and optimize efficiency. Figure 73 reproduces the prototype

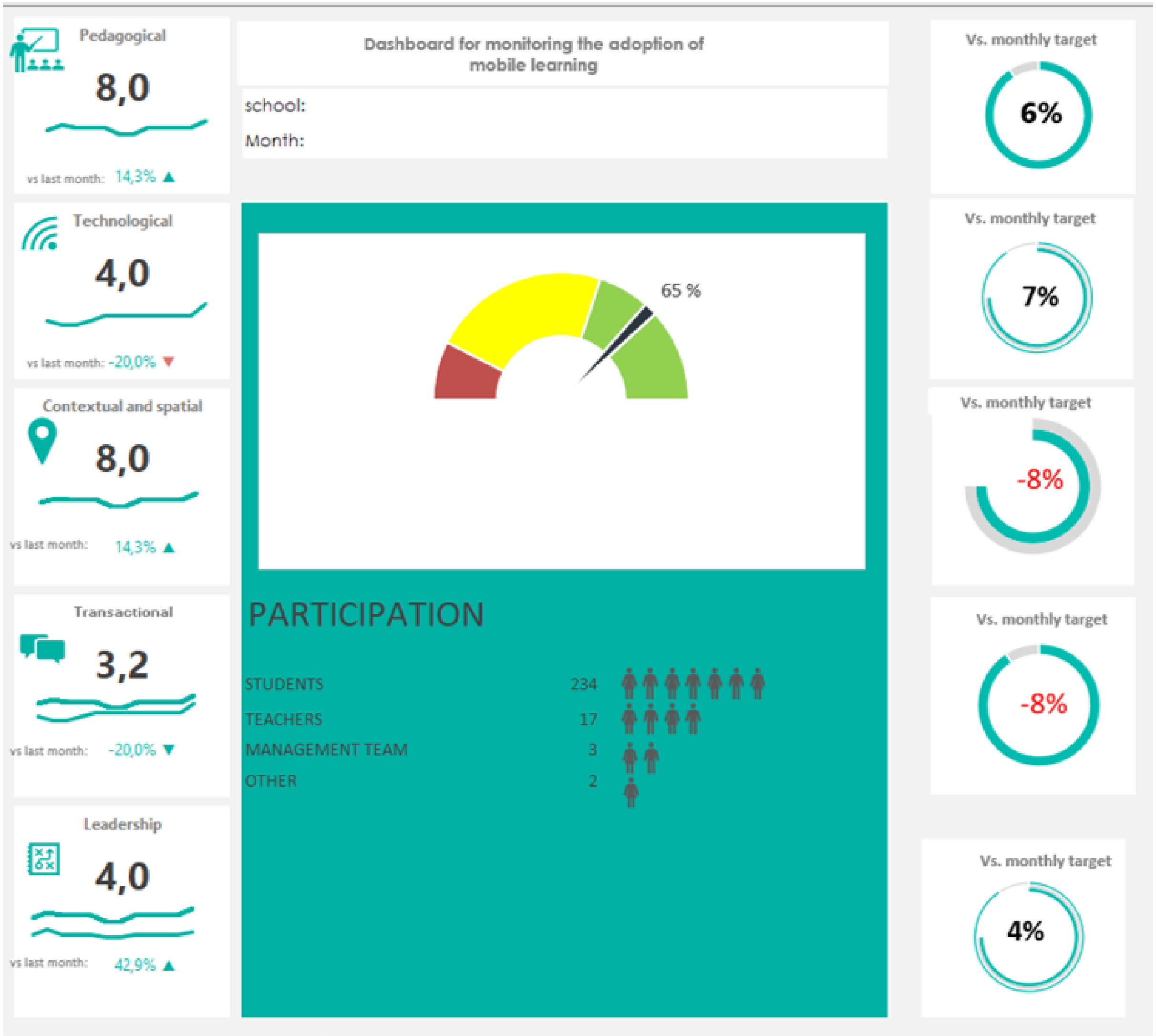


Figure 73. Dashboard for monitoring the adoption of mobile learning

Designing a framework for mobile learning adoption and sustainable development

7.1.6. Mobile learning framework

This last section of the thesis results seeks to answer the sixth research question: RQ6. What are the core elements of a strategic framework for the adoption of mobile learning? The findings are collected in study 9 of this thesis: “A framework for mobile learning adoption and sustainable development “(Chapter 6). The mobile learning framework presented in this article has been developed from the first prototype designed based on the design principles identified in phase two (Chapter 3), refined and adjusted according to the results obtained from the three iterations carried out during phase three (Chapter 4).

For the development of the refined version of the prototype for the adoption of mobile learning, the implication of the design principles adapted to the results of the three iterations carried out has been followed. The first design principle states that the model must have a fundamentally pedagogical basis (Ada, 2018; Churchill et al., 2016; Hwang, 2014; Ng & Nicholas, 2013). Each one of the responsibilities of the five pillars that support the model are eminently pedagogical. School leaders have to guarantee the transfer of knowledge, teachers are responsible for personalized learning coach, students are primarily responsible for developing lifelong and authentic learning, families must complete the creation of horizontal knowledge with the proportion of experiences and others members of the educational community such as politicians or developers have to maintain constant pedagogical innovation. The three iterations that have been developed in this thesis during the third DBR cycle, validate this design principle.

Evaluation as a second design principle (Ada, 2018; Ng & Nicholas, 2013) is explicitly included in the model and developed in the scorecard proposed in chapter 5 of this thesis. The third of the iterations that have been carried out in this thesis during the third phase of the DBR process, validates this design principle and gives it a fundamental relevance to be able to evaluate and monitor the theoretical framework. The 14 identification indicators for the evaluation of mobile learning (Ada, 2018; Crompton, 2017; Kearney et al., 2012; Koole, 2009; Lim Abdullah et al., 2013; Motiwalla, 2007; Ng & Nicholas, 2013; Park, 2011; Rikala, 2015; Sharples & Vavoula, 2009; Veerabhadram et al., 2012); together with the tool developed and proposed in study 8: "dash board for monitoring the adoption of mobile learning" are a relevant complement to this proposed framework.

The third design principle for the adoption of mobile learning is to implement technology as a means , in the proposed model, this principle is formalized in terms of ensuring technology as a resource and the responsibility falls on school leaders, families and children. politicians, leaving to teachers and educators its use as another resource.

The fourth design principle refers to the creation of physical and virtual learning environments to authenticate and contextualize learning (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). Koole (2009) The model includes an explicit section of contextualization and creation of physical and virtual environments and gives the responsibility of their optimization to students, teachers, and families.

The fifth design principle permanently develop digital competence in all members of the educational community, especially teachers and students (Alrasheedi & Capretz, 2015; Cochrane & Bateman, 2010; Ekberg & Gao, 2018; Esteve, 2015; Lu & Viehland, 2008; Mercader, 2018; Rikala, 2015; Sabah, 2016; Stacey & Gerbic, 2008; Tay et al., 2013; Yadegaridehkordi et al., 2013; Yeap et al., 2016). Specifically, the model holds teachers accountable for ensuring ongoing professional development. The first and second iterations contained in this thesis as the third phase of the DBR process to test and validate the theoretical framework, are aimed at identifying the factors that affect the adoption of mobile learning in Catalonia. The results show the relevance that experts and teachers attach to digital literacy. The acquisition of digital competence, in the two investigations, has been highlighted as a key success factor in the adoption of mobile learning.

The sixth design principle for the adoption of mobile learning is to set clear objectives aligned with the mission, vision, and values of the institution. This principle is doubly developed in the proposed model, on the one hand the school leaders are responsible for establishing clear objectives based on the values of the institution, as well as developing regulations and protocols to ensure safety. On the other hand, in the base of the strategic house identified as values, the factors that have had the highest valuation in this category during the first and second iterations of this process are detailed: creativity (Hackman & Johnson, 2013), communication (Crompton, 2013; Crompton & Burke, 2018; Hwang & Tsai, 2011; Karimi, 2016; Koole, 2009; Ozdamli & Cavus, 2011; Rikala, 2015; Tétard et al., 2008) collaboration (Khan, 2005; Bocconi et al. 2013; Spector, 2013), and ethical values (S. Jones, 2017; Kukulska-Hulme, 2008). It is noteworthy the relevance given to this principle by the experts, the category of behaviour, attitudes, and ethics, was identified as the second most valued, after leadership that was the first.

The seventh and final design principle establishes that a holistic approach oriented to systematic change must be followed that is based on the pillars of the educational community: educators, students, leaders, families and other members of the community that includes legislators, instructional designers, developers system. , among others (Ng & Nicholas, 2013). The identified pillars are identified in the proposed model, without undermining the interconnection and constant collaboration between them, essential to optimize the results of the application of the model.

As it has been stated before, the framework designed, provides a strategic and holistic vision for the adoption of mobile learning, which represents an innovation in relation to previous frameworks, and this constitutes the main contribution of this doctoral work.. Despite the identified relevance of evaluation in the mobile learning adoption processes, only two of the studies analyzed include evaluation in their frameworks. The framework includes evaluation as a fundamental element of the strategic process of adoption of mobile learning, furthermore, it has been completed with the design of a scorecard to evaluate, monitor, and adjust the process. This great contribution ensures constant adaptation and consequently sustainability over time, in contrast to many current short-term oriented frameworks (Ng & Nicholas, 2013).

Cisler (2002) developed a framework for the sustainability of ICT in education based on four elements: economic, social, political, and technological sustainability. Ng and Nicholas (2018) added pedagogical as a fifth dimension in sustainability in the mobile learning adoption. The framework presented in this thesis ensures economic sustainability through the management and allocation of resources, a role assigned to the leaders. Political sustainability is guaranteed through the determination of objectives, procedures, protocols by the leaders. Social responsibility is evidenced by the participation of the entire educational community and the promotion of sharing knowledge assigned to the leaders. A relevant aspect to guarantee social sustainability is found in the establishment of regulations to ensure safety. Technological sustainability in the model is linked to the development and coordination of resources, a role that has been assigned to the leaders and other members of the educational community. Finally, pedagogical sustainability is the most represented in the framework:

develop learning designs based on innovative pedagogies, ensure continuous professional development, build physical and virtual learning environments, assign a role central in the students and assign a prominent role to assessment and adjustment.

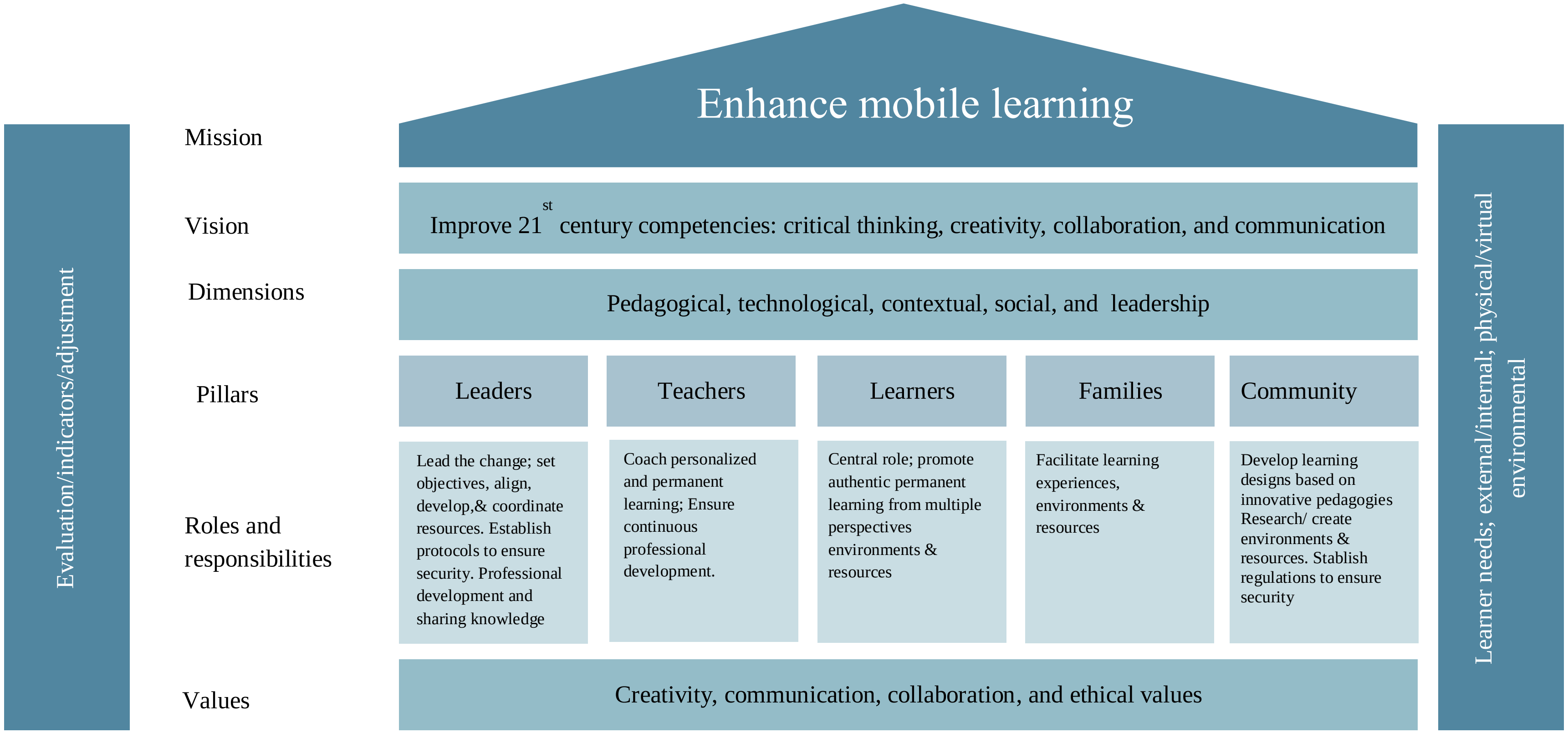


Figure 74. Mobile learning strategic management framework

7.2. Limitation of the study and recommendations for further research

One of the main limitations of the systematic review included in study 1 is that due to the breadth and complexity of the research on this subject, study 1 focuses on previous reviews and not on original studies. Also derived from study 1 on the situation of research in mobile learning, a series of shortcomings have been detected that may guide future research in mobile learning: development of theoretical frameworks for mobile learning, development of efficient procedures and tools to ensure the accurate outcomes' measurement and contextualizing research in secondary education.

The main methodological limitation of study 2 stems from focusing the research on studies that explicitly included definitions of mobile learning. Another methodological limitation refers to the interpretive paradigm that has guided the classifications made by the researchers and the lack of specific contextualization of the study. To apply the results in different contexts and educational levels, it would be necessary for future lines of research to focus on specific settings. As well as validating the causality between characteristics, functionalities and learning principles.

In relation to study 3 a limitation is that the identified design principles are likely to vary 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 ensuring that fundamental design principles are considered. The contribution will also help future research to develop and refine new mobile learning frameworks.

The most significant limitation of study 7 is methodological in relation to the sample size n = 147, the number of surveys required to obtain a 95% confidence level should be 302 surveys. Limitations also reacted with the samples are the convenience and non-probabilistic character of the expert judgment of study 5. The sample of study 7, if it is probabilistic, but both the communication and the instrument are exclusively digital, which may limit the accessibility of some teachers

The main limitation of the study 8 is that no measurement instruments have been developed for the identified indicators, another limitation derived from this study and constant in this thesis is the lack of contextualization of the research, both at the study level, as well as at the geographical or sociocultural level.

The proposed final framework is envisaged to serve as a guide for the educational community regarding implementing sustainable mobile learning. The findings are expected to be useful both for academics and policy makers as insight for further research and successful mobile learning adoption and learning improvements.

As the framework has not been designed for a specific grade level or domain, it will also be necessary to define in what specific scenarios the framework could be adopted. This need requires the study of more in-depth perspectives of the framework to guarantee the generalization of results. Going forward, it would be beneficial for researchers to study the framework in various educational contexts to see if there is anything that has been omitted from the mobile learning integration framework that needs to be added. The current findings are likely to change with ongoing technological developments. The framework also identifies interactions that could be studied in the future.

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Designing a framework for mobile learning adoption and sustainable development

APPENDIXES

APPENDIX 1: Metadata

The metadata tables contained in this thesis can be found at https://sofiamoya5.wixsite.com/sofiamoya

APPENDIX 2: Expert judgement

Expert Judgement Dossier, February 2017

The expert dossier was structured in the following sections:

Introduction

The application of technologies is present in most of our daily routines and deeply transforming our environment in most industries and sectors. We find a significant consistency among experts in including digital competence as one of the most relevant among the different competency models of the 21st century.

Despite the extensive recognition of the need to increase the digitization levels of education, the high levels of device penetration, ubiquity, availability of content, strategies, and implementation models; The reality, in many environments, is deeply analytical. According to an OECD study (Measuring Innovation in Education, 2014) only 14% of European teachers used technologies in more than 50% of their classes.

The general objective of the thesis is the design and development of a strategic management framework for the adoption and sustainable use of Mobile Learning in high school.

Expert Judgement brief

Thank you for participating in this trial of experts, we know that it is a privilege to be able to count on their time, their contributions will be very valuable for our investigation. Once the search is complete, we will send you the obtained conclusions. Your data will remain private throughout the search and its subsequent disclosure.

One of the techniques of data collection used during the second cycle of the investigation, is the opinion of experts. Expert judgement consists of collecting opinions and solutions to specific research objectives, by a group of people recognized by others as qualified experts in a topic and that can provide information, evidence, judgements, and evaluations.

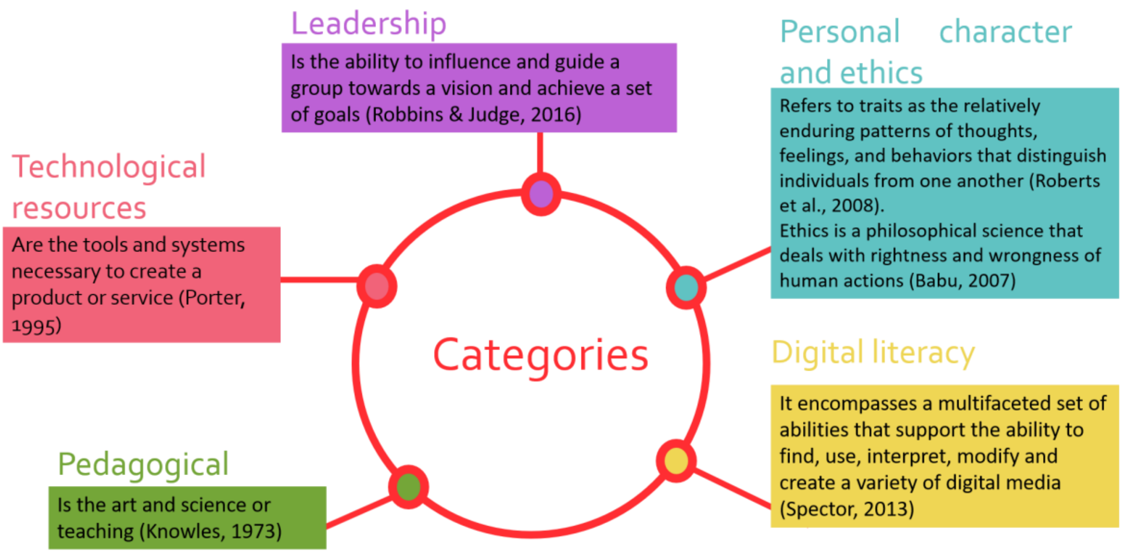
Goals

The specific objective within the framework of our thesis is to develop an initial knowledge of the categories of factors that affect a strategic management framework for the adoption and sustainable use of Mobile Learning in secondary education based on expert judgement. Specifically, the objectives of the current session are:

Validate the definition of categories: technological resources, digital competencies, pedagogy, personal characters, and ethics; and leadership

Consensus the prioritization of the same Validation Number of thematic elements: 5 categories. Number of sub-elements: 50 factors

Obtain evidence of what specific factors encompass each of the categories



Prioritization

Prioritize from one to five the following categories according to their importance in a framework of strategic management for the adoption and sustainable use of Mobile Learning in a secondary environment. Being 1. Very Low, 2. Low, 3. Medium, 4. High, 5. Very High.

1.1 Personal characters and ethics ☐
1.2 Leadership ☐
1.3 Technological resources ☐
1.4 Digital literacy ☐
1.5 Pedagogical ☐

2.Recursos Tecnològics són les eines i sistemes necessaris per crear un producte o servei (Porter, 1995)
Assigni fins a un màxim de deu, els factors que consideri poden encaixar en la categoria de recursos tecnològics (1V). Segona volta, prioritzar (2V).

	1V	2V		1V	2V
2.1 Accés a internet	☐	☐	2.26 Feedback freqüent i constructiu	☐	☐
2.2 Accessibilitat/Rati alumne-dispositiu	☐	☐	2.27 Formació efectiva	☐	☐
2.3 Adaptabilitat de la matèria a ensenyar	☐	☐	2.28 Formulació de l'estratègia	☐	☐
2.4 Assequible	☐	☐	2.29 Gestió de recursos, financers, temps, tecnològics, espa	☐	☐
2.5 Avaluació de l'aprenentatge	☐	☐	2.30 Gestionar canvis cultura organitzativa	☐	☐
2.6 Capacitat organitzativa	☐	☐	2.31 Grups d'aprenentatge (Professors, líders)	☐	☐
2.7 Caràcter	☐	☐	2.32 Guies, processos i polítiques clares	☐	☐
2.8 Col·laboració proactiva i distributiva	☐	☐	2.33 Incentius	☐	☐
2.9 Competències digitals prèvies	☐	☐	2.32.4 Indicadors (KPI's) més gestionables	☐	☐
2.10 Compromís individual	☐	☐	2.35 Integració a l'aula	☐	☐
2.11 Comunicació	☐	☐	2.36 Interacció instructors-alumnes	☐	☐
2.12 Condicions extrínseques favorables, influència social	☐	☐	2.37 Mal funcionament de sistemes	☐	☐
2.13 Conflictes i negociació	☐	☐	2.38 Mantenir i adaptar les competències digitals	☐	☐
2.14 Construir i compartir coneixement	☐	☐	2.39 Mentalitat "digital"	☐	☐
2.15 Creativitat	☐	☐	2.40 Mentalitat oberta	☐	☐
2.16 Disponibilitat de contingut digital i manteniment	☐	☐	2.41 Nivell de confiança en la tecnologia	☐	☐
2.17 Disponibilitat de contingut per a la formació	☐	☐	2.42 Nivell d'integració	☐	☐
2.18 Disponibilitat d'Instructors amb competències digitals	☐	☐	2.43 Participació dels alumnes	☐	☐
2.19 Dispositiu Hardware2	☐	☐	2.44 Personalització/Diversitat	☐	☐
2.20 Dispositiu Software	☐	☐	2.45 Pràctiques i metodologies anteriors	☐	☐
2.21 Distribució de responsabilitats	☐	☐	2.46 Qualitat de l'avaluació i reconeixement de la formació	☐	☐
2.22 Diversificar estratègies d'aprenentatge,	☐	☐	2.47 Rebuig/Prohibició de tecnologies per educació	☐	☐
2.23 Drets de la propietat intel·lectual	☐	☐	2.48 Resistència al canvi	☐	☐
2.24 Entusiasme	☐	☐	2.49 Utilitat	☐	☐
2.25 Expectatives de resultats, d'eficiència i efectivitat	☐	☐	2.50 Visió, objectius i valors visibles, compartits i clars	☐	☐

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3. Lideratge és l'habilitat d'influenciar i guiar a un grup cap a una visió i assolir un conjunt d'objectius (Robbins & Judge, 2016)
Assigni fins a un màxim de deu, els factors que consideri poden encaixar en la categoria de lideratge (1V). Segona volta, prioritzar (2V).

	1V	2V		1V	2V
3.1 Accés a internet	☐	☐	3.26 Feedback freqüent i constructiu	☐	☐
3.2 Accessibilitat/Rati alumne-dispositiu	☐	☐	3.27 Formació efectiva	☐	☐
3.3 Adaptabilitat de la matèria a ensenyar	☐	☐	3.28 Formulació de l'estratègia	☐	☐
3.4 Assequible	☐	☐	3.29 Gestió de recursos, financers, temps, tecnològics, espai	☐	☐
3.5 Avaluació de l'aprenentatge	☐	☐	3.30 Gestionar canvis cultura organitzativa	☐	☐
3.6 Capacitat organitzativa	☐	☐	3.31 Grups d'aprenentatge (Professors, líders)	☐	☐
3.7 Caràcter	☐	☐	3.32 Guies, processos i polítiques clares	☐	☐
3.8 Col·laboració proactiva i distributiva	☐	☐	3.33 Incentius	☐	☐
3.9 Competències digitals prèvies	☐	☐	3.33.4 Indicadors (KPI's) més gestionables	☐	☐
3.10 Compromís individual	☐	☐	3.35 Integració a l'aula	☐	☐
3.11 Comunicació	☐	☐	3.36 Interacció instructors-alumnes	☐	☐
3.12 Condicions extrínseques favorables, influència social	☐	☐	3.37 Mal funcionament de sistemes	☐	☐
3.13 Conflictes i negociació	☐	☐	3.38 Mantenir i adaptar les competències digitals	☐	☐
3.14 Construir i compartir coneixement	☐	☐	3.39 Mentalitat "digital"	☐	☐
3.15 Creativitat	☐	☐	3.40 Mentalitat oberta	☐	☐
3.16 Disponibilitat de contingut digital i manteniment	☐	☐	3.41 Nivell de confiança en la tecnologia	☐	☐
3.17 Disponibilitat de contingut per a la formació	☐	☐	3.42 Nivell d'integració	☐	☐
3.18 Disponibilitat d'Instructors amb competències digitals	☐	☐	3.43 Participació dels alumnes	☐	☐
3.19 Dispositiu Hardware2	☐	☐	3.44 Personalització/Diversitat	☐	☐
3.20 Dispositiu Software	☐	☐	3.45 Pràctiques i metodologies anteriors	☐	☐
3.21 Distribució de responsabilitats	☐	☐	3.46 Qualitat de l'avaluació i reconeixement de la formació	☐	☐
3.22 Diversificar estratègies d'aprenentatge,	☐	☐	3.47 Rebuig/Prohibició de tecnologies per educació	☐	☐
3.23 Drets de la propietat intel·lectual	☐	☐	3.48 Resistència al canvi	☐	☐
3.24 Entusiasme	☐	☐	3.49 Utilitat	☐	☐
3.25 Expectatives de resultats, d'eficiència i efectivitat	☐	☐	3.50 Visió, objectius i valors visibles, compartits i clars	☐	☐

14

4. Pedagogia és l'art i ciència d'ensenyar (Knowles, 1973)

Assigni fins a un màxim de deu, els factors que consideri poden encaixar en la categoria de pedagogia (1V). Segona volta, prioritzar (2V).

	1V	2V		1V	2V
4.1 Accés a internet	☐	☐	4.26 Feedback freqüent i constructiu	☐	☐
4.2 Accessibilitat/Rati alumne-dispositiu	☐	☐	4.27 Formació efectiva	☐	☐
4.3 Adaptabilitat de la matèria a ensenyar	☐	☐	4.28 Formulació de l'estratègia	☐	☐
4.4 Assequible	☐	☐	4.29 Gestió de recursos, financers, temps, tecnològics, espai	☐	☐
4.5 Avaluació de l'aprenentatge	☐	☐	4.30 Gestionar canvis cultura organitzativa	☐	☐
4.6 Capacitat organitzativa	☐	☐	4.31 Grups d'aprenentatge (Professors, líders)	☐	☐
4.7 Caràcter	☐	☐	4.32 Guies, processos i polítiques clares	☐	☐
4.8 Col·laboració proactiva i distributiva	☐	☐	4.33 In2centius	☐	☐
4.9 Competències digitals prèvies	☐	☐	4.32 Indicadors (KPI's) més gestionables	☐	☐
4.10 Compromís individual	☐	☐	4.35 Integració a l'aula	☐	☐
4.11 Comunicació	☐	☐	4.36 Interacció instructors-alumnes	☐	☐
4.12 Condicions extrínseques favorables, influència social	☐	☐	4.37 Mal funcionament de sistemes	☐	☐
4.13 Conflictes i negociació	☐	☐	4.38 Mantenir i adaptar les competències digitals	☐	☐
4.14 Construir i compartir coneixement	☐	☐	4.39 Mentalitat "digital"	☐	☐
4.15 Creativitat	☐	☐	4.40 Mentalitat oberta	☐	☐
4.16 Disponibilitat de contingut digital i manteniment	☐	☐	4.41 Nivell de confiança en la tecnologia	☐	☐
4.17 Disponibilitat de contingut per a la formació	☐	☐	4.42 Nivell d'integració	☐	☐
4.18 Disponibilitat d'Instructors amb competències digitals	☐	☐	4.43 Participació dels alumnes	☐	☐
4.19 Dispositiu Hardware2	☐	☐	4.44 Personalització/Diversitat	☐	☐
4.20 Dispositiu Software	☐	☐	4.45 Pràctiques i metodologies anteriors	☐	☐
4.21 Distribució de responsabilitats	☐	☐	4.46 Qualitat de l'avaluació i reconeixement de la formació	☐	☐
4.22 Diversificar estratègies d'aprenentatge,	☐	☐	4.47 Rebuig/Prohibició de tecnologies per educació	☐	☐
4.23 Drets de la propietat intel·lectual	☐	☐	4.48 Resistència al canvi	☐	☐
4.24 Entusiasme	☐	☐	4.49 Utilitat	☐	☐
4.25 Expectatives de resultats, d'eficiència i efectivitat	☐	☐	4.50 Visió, objectius i valors visibles, compartits i clars	☐	☐

5. Caràcter personal i ètica són estats mentals psicològics que poden determinar comportaments, és a dir, com una persona respon y actua en front a un estímul específic (Robbins & Judge, 2016). Assigni fins a un màxim de deu, els factors que consideri poden encaixar en la categoria de Actituds i comportaments (1V). Segona volta, prioritzar (2V).

	1V	2V		1V	2V
5.1 Accés a internet	☐	☐	5.26 Feedback freqüent i constructiu	☐	☐
5.2 Accessibilitat/Rati alumne-dispositiu	☐	☐	5.27 Formació efectiva	☐	☐
5..3 Adaptabilitat de la matèria a ensenyar	☐	☐	5.28 Formulació de l'estratègia	☐	☐
5.4 Assequible	☐	☐	5.29 Gestió de recursos, financers, temps, tecnològics, espai	☐	☐
5.5 Avaluació de l'aprenentatge	☐	☐	5.30 Gestionar canvis cultura organitzativa	☐	☐
5.6 Capacitat organitzativa	☐	☐	5.31 Grups d'aprenentatge (Professors, líders)	☐	☐
5.7 Caràcter	☐	☐	5.32 Guies, processos i polítiques clares	☐	☐
5.8 Col·laboració proactiva i distributiva	☐	☐	5.33 In2centius	☐	☐
5.9 Competències digitals prèvies	☐	☐	5.32 Indicadors (KPI's) més gestionables	☐	☐
5.10 Compromís individual	☐	☐	5.35 Integració a l'aula	☐	☐
5.11 Comunicació	☐	☐	5.36 Interacció instructors-alumnes	☐	☐
5.12 Condicions extrínseques favorables, influència social	☐	☐	5.37 Mal funcionament de sistemes	☐	☐
5.13 Conflictes i negociació	☐	☐	5.38 Mantenir i adaptar les competències digitals	☐	☐
5.14 Construir i compartir coneixement	☐	☐	5.39 Mentalitat "digital"	☐	☐
5.15 Creativitat	☐	☐	5.40 Mentalitat oberta	☐	☐
5.16 Disponibilitat de contingut digital i manteniment	☐	☐	5.41 Nivell de confiança en la tecnologia	☐	☐
5.17 Disponibilitat de contingut per a la formació	☐	☐	5.42 Nivell d'integració	☐	☐
5.18 Disponibilitat d'Instructors amb competències digitals	☐	☐	5.43 Participació dels alumnes	☐	☐
5.19 Dispositiu Hardware2	☐	☐	5.44 Personalització/Diversitat	☐	☐
5.20 Dispositiu Software	☐	☐	5.45 Pràctiques i metodologies anteriors	☐	☐
5.21 Distribució de responsabilitats	☐	☐	5.46 Qualitat de l'avaluació i reconeixement de la formació	☐	☐
5.22 Diversificar estratègies d'aprenentatge,	☐	☐	5.47 Rebuig/Prohibició de tecnologies per educació	☐	☐
5.23 Drets de la propietat intel·lectual	☐	☐	5.48 Resistència al canvi	☐	☐
5.24 Entusiasme	☐	☐	5.49 Utilitat	☐	☐
5.25 Expectatives de resultats, d'eficiència i efectivitat	☐	☐	5.50 Visió, objectius i valors visibles, compartits i clars	☐	☐

6. Competències digitals engloba un conjunt d'habilitats polifacètiques que suporten l'habilitat de trobar, utilitzar, interpretar, modificar i crear una varietat de mitjans digitals (Spector, 2013). Assigni fins a un màxim de deu, els factors que consideri poden encaixar en la categoria de competències digitals (1V). Segona volta, prioritzar (2V).

	1V	2V		1V	2V
6.1 Accés a internet	☐	☐	6.26 Feedback freqüent i constructiu	☐	☐
6.2 Accessibilitat/Rati alumne-dispositiu	☐	☐	6.27 Formació efectiva	☐	☐
6..3 Adaptabilitat de la matèria a ensenyar	☐	☐	6.28 Formulació de l'estratègia	☐	☐
6.4 Assequible	☐	☐	6.29 Gestió de recursos, financers, temps, tecnològics, espai	☐	☐
6.5 Avaluació de l'aprenentatge	☐	☐	6.30 Gestionar canvis cultura organitzativa	☐	☐
6.6 Capacitat organitzativa	☐	☐	6.31 Grups d'aprenentatge (Professors, líders)	☐	☐
6.7 Caràcter	☐	☐	6.32 Guies, processos i polítiques clares	☐	☐
6.8 Col·laboració proactiva i distributiva	☐	☐	6.33 In2centius	☐	☐
6.9 Competències digitals prèvies	☐	☐	6.32 Indicadors (KPI's) més gestionables	☐	☐
6.10 Compromís individual	☐	☐	6.35 Integració a l'aula	☐	☐
6.11 Comunicació	☐	☐	6.36 Interacció instructors-alumnes	☐	☐
6.12 Condicions extrínseques favorables, influència social	☐	☐	6.37 Mal funcionament de sistemes	☐	☐
6.13 Conflictes i negociació	☐	☐	6.38 Mantenir i adaptar les competències digitals	☐	☐
6.14 Construir i compartir coneixement	☐	☐	6.39 Mentalitat "digital"	☐	☐
6.15 Creativitat	☐	☐	6.40 Mentalitat oberta	☐	☐
6.16 Disponibilitat de contingut digital i manteniment	☐	☐	6.41 Nivell de confiança en la tecnologia	☐	☐
6.17 Disponibilitat de contingut per a la formació	☐	☐	6.42 Nivell d'integració	☐	☐
6.18 Disponibilitat d'Instructors amb competències digitals	☐	☐	6.43 Participació dels alumnes	☐	☐
6.19 Dispositiu Hardware2	☐	☐	6.44 Personalització/Diversitat	☐	☐
6.20 Dispositiu Software	☐	☐	6.45 Pràctiques i metodologies anteriors	☐	☐
6.21 Distribució de responsabilitats	☐	☐	6.46 Qualitat de l'avaluació i reconeixement de la formació	☐	☐
6.22 Diversificar estratègies d'aprenentatge,	☐	☐	6.47 Rebuig/Prohibició de tecnologies per educació	☐	☐
6.23 Drets de la propietat intel·lectual	☐	☐	6.48 Resistència al canvi	☐	☐
6.24 Entusiasme	☐	☐	6.49 Utilitat	☐	☐
6.25 Expectatives de resultats, d'eficiència i efectivitat	☐	☐	6.50 Visió, objectius i valors visibles, compartits i clars	☐	☐

Table 66. Factors description (Catalan)

FACTOR	DESCRIPCIÓ	CITAT COM A FACTOR PER L'AUTOR
1 Accés a internet	Connexió electrònica a una xarxa de comunicació Factors concrets són fiabilitat, velocitat i temps de descàrrega de continguts	Navigation ((B. H. Khan, 2005)
2 Accessibilitat/Rati alumne-dispositiu	Capacitat de poder utilitzar un dispositiu. Nombre d'alumnes per cada dispositiu	Accessability (Khan, 2005)
3 Adaptabilitat de la matèria a ensenyar	Dificultat per adaptar el contingut d'una matèria per ser digitalitzat	Adaptability of the course to being taught through ICT (Soong et al., 2001)
4 Assequible	La capacitat d'adquirir recursos sense detriments significatius	Affordability (Olafsen 2005)
5 Avaluació de l'aprenentatge	Establir els resultats esperats durant l'aprenentatge de manera clara i mesurable	Assessing student learning (Woolf, 2010 cited by Spector 2013)
6 Capacitat organitzativa	És un terme que s'utilitza per descriure una varietat de capacitats, recursos i coneixements necessaris per gestionar una organització	Organizational capacity (Orcutt & AlKadri, 2009)
7 Caràcter	La combinació de característiques i qualitats que identifiquen la personalitat	Personality traits (Fresen & Lesley, 2006)
8 Col·laboració proactiva i distributiva	És una estratègia que promou els beneficis de compartir i distribuir recursos	Better collaboration using online distribution boards (Soong et al., 2001)
9 Competències digitals prèvies	Competència digital és un concepte que evoluciona i engloba competències relatives a la utilització de tecnologia Literatura digital sovint s'utilitza com a sinònim	Teachers digital competencies (Bocconi et al., 2013)
10 Compromís individual	Voluntat formal o informal per part d'una persona de satisfer una obligació	Commitment (Guohui & Eppler, 2008)
11 Comunicació	Es la transferència i comprensió de significat entre un emissor i receptor	Communication (Khan, 2005)
12 Condicions extrínseques favorables, influència social	Influència social és l'efecte que el comportament d'una persona o grup de persones exerceixen sobre d'altres	Extrinsic motivators: facilitating conditions (Khan, 2005)
13 Conflictes i negociació	Conflicte é son procés que comença quan una part percep que l'altra part té un efecte negatiu sobre algun cosa que li importa Negociació és un procés en el que dues o més parts intercanvien bens o serveis amb la intenció d'arribar a un acord	Conflict and negotiations (Khan, 2005)
14 Construir i compartir coneixement	Compartir coneixement és una part fonamental de la gestió del coneixement que consisteix en recollir, organitzar, analitzar i compartir coneixement en forma de recursos, documents i habilitats personals	Knowledge construction (Hao et al., 2017)
15 Creativitat	Capacitat per inventar o crear	Credibility (Hackman & Johnson, 2013)
16 Disponibilitat de contingut digital i manteniment	Disponibilitat de contingut digitalitzat fonamentalment curricular i actualitzacions periòdiques	Availability of educational software (Soong et al., 2001)

17 Disponibilitat de contingut per a la formació	Disponibilitat de contingut digitalitzat per formar a persones en competència digital	Content readiness (Fresen & Lesley, 2006)
18 Disponibilitat d'Instructors al centre amb competències digitals	Poder accedir a persones que actuïn com a instructors i tinguin les competències digitals necessàries	Instructor technical competence (Khan, 2005)
19 Dispositiu Hardware	Dispositiu físic d'una tecnologia determinada	Device (Soong et al., 2001)
20 Dispositiu Software	Disponibilitat de programes i aplicacions que utilitza un dispositiu per realitzar determinades activitats	Software (Olafsen & Cetindamar, 2005)
21 Distribució de responsabilitats	És un concepte vinculat a la distribució de lideratge, implica transferir el lideratge i responsabilitat des de les posicions més altes de l'organigrama cap a baix Pot ser formal o pragmàtic i habitualment és creixent a mesura que es desenvolupen i demostren capacitats	Distribute responsibility (Eide & Søreide, 2014)
22 Diversificar estratègies d'aprenentatge, projectes, interactivitat, competències múltiples.	Estratègies d'aprenentatge estan es refereixen a pensaments, sentiments i accions auto generats pels alumnes i sistemàticament orientades a assolir determinats objectius i competències	Learning strategies (Goyal et al., 2010)
23 Drets de la propietat intel·lectual	Són drets atorgats a les persones o entitats que han creat alguna cosa com art, software, marques etc… habitualment són el dret exclusiu sobre la creació durant un període determinat de temps	Intellectual property rights (Sharples, 2013)
24 Entusiasme	És un sentiment d'interès energètic en un tema o activitat i afany de participar	Enthusiastic teachers (Fresen & Leseley, 2006)
25 Expectatives de resultats, d'eficiència i efectivitat	Expectatives és refereix al sentiment anticipat que alguna cosa passarà Concretament resultats, millora de l'eficiència i/o efectivitat	Expectations of efficiency and effectiveness (Yoo et al., 2012)
26 Feedback freqüent i constructiu	Feedback és la transmissió i comunicació de informació avaluativa o correctiva sobre una acció, esdeveniment o procés	Frequent and constructive feedback to students
27 Formació efectiva	Formació és un procés sistemàtic e interactiu per dissenyar instrucció o entrenament per assolir certes competències i millorar el rendiment. De manera efectiva es refereix a assolir un resultat desitjat amb èxit	Effective training (Egberg & Shang, 2017)
28 Formulació de l'estratègia	Estratègia és un procés orientat a prendre decisions fonamentals i executar accions per assolir determinats objectius	Strategy formulation (Guohui & Eppler, 2008)
29 Gestió de recursos, financers, temps, tecnològics, espai	És el procés d'assignar inutilitzar els recursos d'una organització de la manera més eficient possible Recursos tangibles són bàsicament tecnològics, equipaments i financers; intangibles són persones	Time management (Yoo et al., 2012)
30 Gestionar canvis cultura organitzativa	Cultura organitzativa és el conjunt de valors, creences i comportaments d'una organització Determina com les persones interpreten experiències i actuen en base a uns valors i creences	Addressing policy changes 7 (Woolf, 2010 cited by Spector 2013)
31 Grups d'aprenentatge (Professors, líders)	És una forma activa d'aprenentatge, on els estudiants treballen conjuntament en grups	Group learning (Fresen & Leseley, 2006)

	petits per adquirir i compartir coneixement i assolir habilitats	
32 Guies, processos i polítiques clares	Pautes clares i concretes, basades en els valors organitzatius, orientades a assolir objectius concrets i en última instància la visió de l'organització	Clear guidelines and framework (Khan, 2005)
33 Incentius	Són instruments per motivar a les persones Generalment són monetaris i no monetaris. Aquests últims poden ser oportunitats, flexibilitat horària, formació, millores a l'entorn de treball, reconeixement vacances Aquests últims habitualment estan lligats a motivacions intrínseques i són més efectius a llarg plac, mentre que els monetaris són efectius a curt termini (Maslow's hierarchy of needs)	Incentives (Schaap, 2006) cited by (Guohui & Eppler, 2008)
34 Indicadors (KPI's) més gestionables	Principals indicadors, paràmetres i mesures associats a assolir objectius Principals indicadors de rendiment	Learner -cantered environment (Goyal et al., 2010)
35 Interacció a l'aula	Interacció a l'aula es refereix a la interacció social fins l'aula en funció de la forma i contingut	Classroom interaction (Khan, 2005)
36 Interacció instructors-alumnes en matèria digital	Facilitar i proporcionar interacció entre instructors i alumnes en matèria educativa	Interaction among students and with the lecturer (Volery & Lord, 2000)
37 Mal funcionament de sistemes	Incapacitat de funcionar o no oferir els resultats esperats	Malfunctioning IT (Egberg & Shang, 2017)
38 Assolir, Mantenir i adaptar les competències digitals	Adquirir, mantenir i adaptar les competències digitals necessàries per desenvolupar i potenciar el Mobile Learning	Knowledge construction (Hao et al., 2017)
39 Mentalitat "digital"	És una actitud mental que predisposa respostes positives e interpretacions favorables a determinades situacions relacionades amb la tecnologia digital	E-learning mindset (Fresen & Leseley, 2006)
40 Mentalitat oberta	Tenir una predisposició receptiva i sense perjudicis a noves idees, projectes, argumentacions i canvis	Teacher's open minds (Khan, 2005)
41 Nivell de confiança en la tecnologia	Nivell de confiança indica la probabilitat que un resultat estadístic sigui correcte i no casual	Trust in technology (Egberg & Shang, 2017)
42 Nivell d'integració de recursos tecnològics	És la utilització de diferents recursos tecnològics: ordinadors, tauletes, telèfons, càmeres digitals, pissarres digitals etc… De manera accessible, coordinada i transparent	Level of interaction (Rikala, 2015)
43 Participació dels alumnes	Es l'acte de compartir i involucrar-se en les activitats o iniciatives d'un grup	Student participation (Papp, 2000)
44 Personalització/Diversitat	Utilitzar la tecnologia per acomodar les diferencies entre individus	Customization (Graf & Caines; 2004)
45 Pràctiques i metodologies anteriors	Pràctiques són hàbits, costums, coneixements, generalment assolits a base de repeticions	Teachers practicies (Koole, 2009)
46 Qualitat de l'avaluació i reconeixement de la formació	Avaluació és un procés continu per establir de manera clara i mesurable els resultats esperats d'aprenentatge dels estudiants, garantint les oportunitats suficients mitjançant el recolliment, anàlisi i interpretació sistemàtic d'evidències per determinar si l'aprenentatge assoleix les expectatives	Type and quality of student assessment (Volery & Lord, 2000)

47 Rebuig/Prohibició de tecnologies per educació	Resistència, enfrontament o oposició a una idea acció o situació	Reluctancy to use mobile devices for educational purposes (Fresen & Leseley, 2006)
48 Resistència al canvi	Són accions per part de persones o grups de persones quan precedeixen un canvi com una amenaça per a ells. Resistència pot adoptar moltes formes, generalment s'agrupen en actives i passives.	Resistance to change (Orcutt, 2009)
49 Grau d'usabilitat"	Nivell en que productes i sistemes són fàcils d'utilitzar i són més propers a les necessitats i requisits de l'usuari	Usability (Khan, 2005)
50 Visió, objectius i valors visibles, compartits i clars	Visió és un enunciat de la raó per a la qual una organització existeix. Visió és un enunciat que indica cap a quina direcció una organització és vol dirigir, els valors són les filosofies i principis que guien la conducta interna de la companyia, així com les relacions amb terceres persones.	Lack of clear vision and mission (Egberg & Shang, 2017)

Videos recorded during the expert judgement

https://www.youtube.com/watch?v=s_cE3-pvGQ8

Permission is required, please contact sofia.moya@urv.cat

APPENDIX 3: Questionnaire

Questionnaire structure and results

Questionnaire validation model

Comprehension: 1 easy to understand- 5 very difficult

Relevance: 1 relevance: 1 very relevant – 5 irrelevance

Importance: 1 very important – 5 not important

QUESTION	COMPREHENSION	RELEVANCE	IMPORTANCE

UNIVERSITAT
ROVIRA i VIRGILI

Invitation e-mail

Tarragona 4 October 2020

Dear school director

My name is Sofia Moya and I am doing a doctoral thesis at Rovira I Virgili University on the adoption and sustainable use of mobile learning.

I would like to invite you to help me to distribute a questionnaire that I have constructed as part of my research on frameworks to sustainable use of mobile learning. I am inviting you as school leader. Your school leaders, teachers, opinions on this subject would be highly appreciated. No preparation work is required and the questionnaire will take between. 5 and 10 minutes to complete.

Yours sincerely.

Benvolguda senyora,

Benvolgut senyor,

El meu nom és Sofia Moya I estic realitzant una tesi doctoral a la Universitat Rovira I Virgili sobre l'adopció i ús sostenible de l'aprenentatge mòbil.
M'agradaria convidar-la/convidar-lo a ajudar-me a distribuir un qüestionari que forma part de la investigació. Les opinions dels docents són molt importants pel desenvolupament de la tesi. No porta més 5-10 minuts i es pot distribuir mitjançant el telèfon mòbil.
Moltes gràcies per la seva col·laboració

Salutacions Cordials

Qüestionari URL: *shorturl.at/kuPT4*

Qüestionari QR:

Sofía Moya

E-mailing details

Table 67. E-mailing sent to schools in February 2019 and October 2019

PROVINCE /PROVÍNCIA	EDUCATIONAL LEVEL/ NIVELL EDUCATIU	SCHOOL/CENTRE	PUBLIC-PRIVATE/ PÚBLIC-PRIVAT
Tarragona	Primària i infantil	Institut Coster de la Torre	Públic
Tarragona	Primària i infantil	Escola Eugeni d'Ors	Públic
Tarragona	Primària i infantil	Escola Mare de Déu de la Candela	Públic
Tarragona	Primària i infantil	Escola Jaume I	Públic
Tarragona	Primària i infantil	Escola El Miracle	Públic
Tarragona	Secundària	Institut de l'Ebre	Públic
Tarragona	Secundària	Joan XXIII	Privat
Tarragona	Secundària	Institut Narcís Oller	Públic
Tarragona	Secundària	Institut Andreu Nin	Públic
Tarragona	Secundària	Institut Terra Alta	Públic
Lleida	Primària i infantil	Escola Macià-Companys	Públic
Lleida	Primària i infantil	Escola Mare de Déu del Carme	Públic
Lleida	Primària i infantil	Escola Santa Creu	Públic
Lleida	Primària i infantil	Escola Pia de Balaguer	Privat
Lleida	Primària i infantil	Escola Francesc Feliu	Públic
Lleida	Secundària	Vedruna Balaguer	Privat
Lleida	Secundària	Sagrada Família	Privat
Lleida	Secundària	Institut Caparrella	Públic
Lleida	Secundària	Institut Joan Oró	Públic
Lleida	Secundària	Institut La Segarra	Públic
Girona	Primària i infantil	Escola del Far d'Empordà	Públic
Girona	Primària i infantil	Escola Sant Jordi	Públic
Girona	Primària i infantil	Escola Carles Faust	Públic
Girona	Primària i infantil	Escola Pere Rosselló	Públic
Girona	Primària i infantil	Escola Vall d'Aro	Públic
Girona	Secundària	Institut Ramon Muntaner	Públic
Girona	Secundària	Institut Narcís Monturiol	Públic
Girona	Secundària	La Salle	Privat
Girona	Secundària	Montessori-Palau	Privat
Girona	Secundària	Immaculada Concepció	Privat
Barcelona	Primària i infantil	Escola Lola Anglada	Públic
Barcelona	Primària i infantil	Escola Can Clos	Públic
Barcelona	Primària i infantil	Escola Drassanes	Públic
Barcelona	Primària i infantil	Escola Rius i Taulet	Públic
Barcelona	Primària i infantil	Escola Baldiri Reixac	Públic
Barcelona	Primària i infantil	Escola Elisenda de Montcada	Públic
Barcelona	Primària i infantil	Escola Rambleta del Clot	Públic
Barcelona	Primària i infantil	Jesús Maria	Privat
Barcelona	Primària i infantil	Jesuïtes Sarrià - Sant Ignasi	Privat
Barcelona	Primària i infantil	Escola Pia-Luz Casanova	Privat
Barcelona	Secundària	Institut La Pineda	Públic
Barcelona	Secundària	Jesuïtes Sarrià - Sant Ignasi	Privat

Barcelona	Secundària	Sant Francesc Xavier	Privat
Barcelona	Secundària	Pérez Iborra	Privat
Barcelona	Secundària	Canigó	Privat
Barcelona	Secundària	Sant Pau	Privat
Barcelona	Secundària	Institut Milà i Fontanals	Públic
Barcelona	Secundària	Marillac	Privat
Barcelona	Secundària	Valldaura	Privat
Barcelona	Secundària	Institut Narcís Monturiol	Públic

Social Network

Table 68. Social network distribution sites

	WEB	FOLLOWERS/POSTS
Facebook :Aprofitem el carnet docent	https://www.facebook.com/groups/Aprofitem.el.carnet.docent/	21.864
Facebook: trasllats professors i mestres	https://www.facebook.com/groups/trasllat/	11.504
Facebook: Interins	https://www.facebook.com/groups/170055996972393/	9.838
Instagram:#opos	https://www.instagram.com/explore/tags/opos/?hl=en	98.135
Instagram:#educació	https://www.instagram.com/explore/tags/educaci%C3%B3/?hl=en	53.644
Instagram: #Oposicions2019	https://www.instagram.com/explore/tags/oposicions2019/?hl=en	962
Twitter: @educació.cat	https://twitter.com/educaciocat	62.500
Twitter:@laconcertada	https://twitter.com/laconcertada	894

Questionnaire

Qüestionari URL:

Http://shorturl.at/zHQRZ

Table 69. Questionnaire constructs and questions

CONSTRUCTO	#RAND.	#	PREGUNTA EN CATALÁN	TIPO DE PREGUNTA
Consentimiento		1	Consentiment	Cerrada
Biodata		2	Nom	Abierta
Biodata		3	Gènere	Cerrada
Biodata		4	Edat	Abierta
Biodata		5	Correu electrònic (opcional)	Abierta
Biodata		6	Nivell educatiu on exerceix la docència	Cerrada
Biodata		7	Província	Cerrada
Biodata		8	Anys d'experiència docent	Cerrada
Biodata		9	Tipus de centre on exerceix la docència	Cerrada
Recursos tecnológicos	16	10	La navegació i connectivitat a internet és crucial per implementar l'ús de dispositius mòbils a les aules	Escala 5- point Likert
Recursos tecnológicos	10	11	Tenir una bona eina digital és indispensable per adoptar l'aprenentatge mòbil	Escala 5- point Likert
Recursos tecnológicos	15	12	Disponibilitat de software i recursos és essencial per l'adopció de dispositius mòbils a les aules	Escala 5- point Likert
Alfabetización digital	26	13	La comunitat educativa ha de ser competent en tecnologies digitals per adoptar l'aprenentatge mòbil	Escala 5- point Likert
Alfabetización digital	13	14	Formació i mantenir les competències digitals és prioritari per l'adopció de l'aprenentatge mòbil	Escala 5- point Likert
Alfabetización digital	18	15	La competència digital dels docents, s'ha d'avaluar per garantir l'adopció de l'aprenentatge mòbil	Escala 5- point Likert
Pedagógicos	11	16	L'adopció de l'aprenentatge mòbil requereix estratègies pedagògiques adequades	Escala 5- point Likert
Pedagógicos	23	17	Sense una bona avaluació inclusiva l'adopció d'aprenentatge mòbil no és factible	Escala 5- point Likert
Pedagógicos	17	18	L'avaluació s'ha d'adaptar per avaluar als estudiants per poder adoptar l'aprenentatge mòbil	Escala 5- point Likert
Comportamientos, actitudes i ética	12	19	Una actitud positiva i voluntat de canvi és important per garantir l'adopció de l'aprenentatge mòbil	Escala 5- point Likert
Comportamientos,	14	20	L'ètica i els problemes morals de la utilització de	Escala 5- point

actitudes i ética			tecnologia digital han d'estar regulats i controlats	Likert
Comportamientos, actitudes i ética	19	21	L'adopció de l'aprenentatge mòbil requereix alts nivells de compromís per part de tota la comunitat educativa	Escala 5- point Likert
Comportamientos, actitudes i ética	24	22	La resistència al canvi és un dels factors determinants a l'hora d'implementar l'aprenentatge mòbil	Escala 5- point Likert
Liderazgo	20	23	Guies i estratègies clares a tota la comunitat educativa, són importants per l'adopció de l'aprenentatge amb dispositius mòbils	Escala 5- point Likert
Liderazgo	22	24	Una cultura que promogui l'adopció de dispositius mòbils és un factor clau perquè l'adopció sigui un èxit	Escala 5- point Likert
Liderazgo	25	25	La comunicació i col·laboració són fonamentals per adoptar l'aprenentatge mòbil	Escala 5- point Likert
Liderazgo	21	26	Tenir protocols i pautes ben definits és imprescindible per l'adopció de l'aprenentatge mòbil	Escala 5- point Likert
Abierta		27	Quins factors creus que són els més rellevants per adoptar l'aprenentatge amb dispositius mòbils?	Abierta

APPENDIX 4: Compendium of articles

This Doctoral Thesis is presented in the modality of "Doctoral Thesis as a compendium of publications "in accordance with the Academic Regulation and legislation of Doctorate of the Governing Council of February 25, 2016; and the provisions of article 11.6 of Royal Decree 99/2011, of 28 January.

Therefore, and to comply with the requirements included in the regulations, the following information is attached:

- Authorization of the thesis supervisor Dra. Mar Camacho i Martí, for the presentation of the thesis.
- Statement by the co-authors for each article submitted.

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I STATE that the present study, entitled "Designing a framework for mobile learning adoption and sustainable development" presented by Sofia Moya Pereira for the award of the degree of Doctor, has been carried out under my supervision at the Department of Pedagogy and that it satisfies all requirements to be eligible for the International Doctorate Award.

Tarragona, November 2020

Dr. Mar Camacho i Martí

Doctoral Thesis Supervisor

Dra. Mercè Gisbert i Cervera

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Hereby Dr. Mar Camacho Martí, coauthor of the articles with the following papers:

Moya, S., & Camacho, M. (2020). A taxonomy of Mobile Learning based on Systematic Review. International Journal of Mobile Learning and Organization, 14(4), 425–455. https://doi.org/10.1504/IJMLO.2020.10030686

Moya, S., & Camacho, M. (In press). Design principles of mobile learning frameworks. International Journal of Mobile and Blended Learning, 13(1). https://doi.org/10.4018/IJMBL.202101

Moya, S., & Camacho, M. (2018). Planning to Implement Change: Strategic Pillars to Lead Mobile Learning in the Secondary School Environment. Conference: International Conference on Open and Innovative EducationAt: Hong Kong, 205–221. https://bit.ly/2keIkF8

Moya, S., & Camacho, M. (2019). What factors matter most for mobile learning adoption? Proceedings of the 15th International Conference on Mobile Learning 2019, ML 2019. https://doi.org/10.33965/ml2019_201903l004

Moya, S., & Camacho, M. (2020). Factores que afectan la adopción de mobile learning en Cataluña. In UMA editorial (Ed.), XXIII Congreso Internacional Edutec (pp. 783–786).

Declare:

Her agreement with the use of these scientific articles as part of the compendium of publications that Sofia Moya Pereira will present for the purpose of formulating her Doctoral Thesis as a compendium of publications
Her commitment not to lend this scientific article as part of another Doctoral Thesis.
The participation of Sofia Moya Pereira as the main author of these articles contributing to the preparation of the articles.
Tarragona, October 2020

Dr. Mar Camacho Martí

UNIVERSITAT ROVIRA i VIRGILI

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Hereby Dr. Ramon Felix Palau Martin, coauthor of the following paper:

Moya, S., Camacho, M., & Palau, R. (2020). Cuadro de mando para el seguimiento en la adopción del mobile learning en educación. In U. A. de Barcelona (Ed.), *VI Congreso Internacional EDO 'La nueva gestión del conocimiento'*.

Declare:

His agreement with the use of these scientific articles as part of the compendium of publications that Sofia Moya Pereira will present for the purpose of formulating her Doctoral Thesis as a compendium of publications

His commitment not to lend this scientific article as part of another Doctoral Thesis.

Tarragona, November 2020

Dr. Ramon Felix Palau Martin

Designing a framework for mobile learning adoption and sustainable development

APPENDIX 5: International mention in the doctoral diploma

The mention of "International Doctor" is requested for the PhD student, in compliance with the Academic Regulation and legislation of Doctorate of the Governing Council of February 25, 2016; and what is stated in article 15, Royal Decree 1393/2007, of October 29, which regulates Doctoral Programs.

Therefore, and to comply with the requirements included in the regulations, the following information is attached

Accreditation of a three-month research stay at "Wuyi University", 五一大射, Jiangmen, China. under the supervision and supervision of professor Dr. Gerald Teng.

Accreditation of a two-year research stay at "Wuyi University", 五一大射, Jiangmen, China.

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Dear Madam, dear Sir,

I hereby confirm that Mrs. Sofia Moya Pereira has successfully completed her teaching and research in Wuyi University, Jiangmen, Guangdong, China from 1st October 2016 to 10th July 2018.

The topic of her teaching was Mobile Learning.

It was a pleasure to host Mrs. Sofia Moya Pereira in Wuyi University.

I wish her all the best for her future professional career

Kind regards

王淳阳

Dr. WANG Chunyang

Director, Foreign Affairs Office

Wuyi University

Jiangmen, Guangdong

China

WUYI UNIVERSITY, JIANGMEN, GUANGDONG, CHINA 529020
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APPENDIX 6: Published studies links

6.1 A taxonomy of mobile learning based on a systematic review

Moya, S., & Camacho, M. (2020). A taxonomy of Mobile Learning based on Systematic Review. *International Journal of Mobile Learning and Organization*, 14(4), 425–455. https://doi.org/10.1504/IJMLO.2020.10030686

https://www.inderscience.com/offer.php?id=110782

Int. J. Mobile Learning and Organisation, Vol. 14, No. 4, 2020 425

A taxonomy of mobile learning based on a systematic review

Sofia Moya* and Mar Camacho

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Faculty of Education,
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Abstract: This study seeks to deepen the understanding of existing mobile learning research, summarise the relevant knowledge and identify research gaps. This study is based on a systematic review of relevant studies conducted between 2009 and 2018; the pool of studies comprised 25 studies, representing a total of 1828 original publications. A taxonomy was proposed based on 13 taxonomies, which were grouped into five domains: bibliometric statistics, research purposes, demographics and context, methodologies and outcomes. The findings revealed the following: the number of articles published has increased over the last years, with significant contributions from Asia; most studies feature positive outcomes; the main focus is on learning effectiveness; the majority of the target sample comprises students, and the environment is hybrid, with a tendency to be informal; and mixed research methodologies are the common trend. The results also revealed a lack of current research in the field of strategies and frameworks.

Keywords: mobile technology support learning; teaching strategies; blended learning; m-learning; ubiquitous learning.

Reference to this paper should be made as follows: Moya, S. and Camacho, M. (2020) 'A taxonomy of mobile learning based on a systematic review', *Int. J. Mobile Learning and Organisation*, Vol. 14, No. 4, pp.425–455.

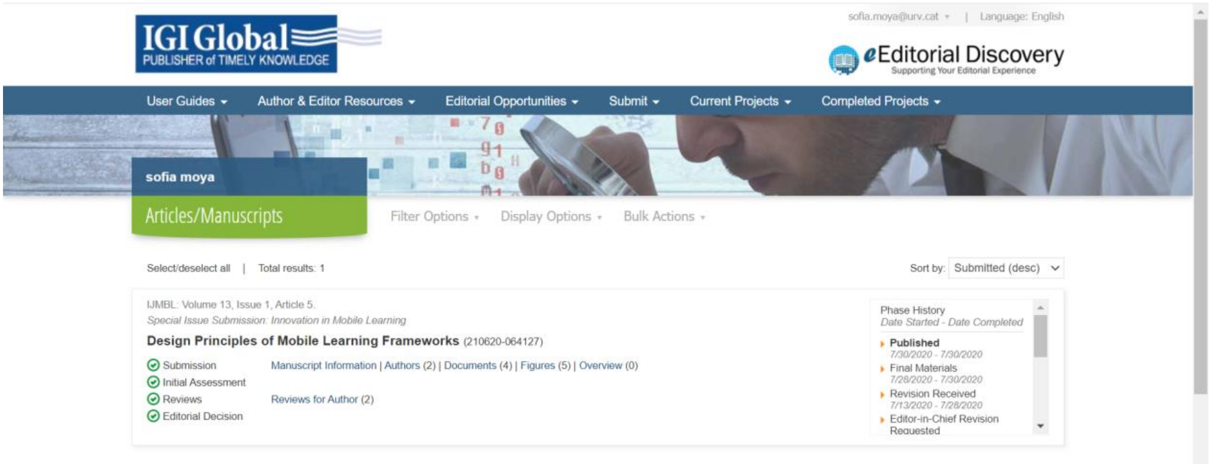
Biographical notes: Sofia Moya received the BA and MA from ESADE Business School, Barcelona. She is a PhD candidate in Educational Technology, Universitat Rovira I Virgili, Spain. She spent two years at Wuyi University in China as an Associate Professor. She is currently an Associate Professor in the Department of Educational Technology, Universitat Rovira I Virgili, Spain. Her research interests are in the area of mobile learning.

Mar Camacho received the BA and PhD from Universitat Rovira I Virgili, Spain, in 1993 and 2006, respectively. She is currently General Director of primary and secondary education for the Generalitat de Catalunya, the government of Catalunya, and Lecturer in the Faculty of pedagogy, Universitat Rovira I Virgili. She was Researcher at the Applied Research Group on Educational Technology (ARGET). She is the author of more than 75 research publication in the area of Educational Technology. Her research interests are in the area of mobile learning. Her research interests are in the area of mobile learning.

6.2 Design principles of mobile learning frameworks

Moya, S., & Camacho, M. (In press). Design principles of mobile learning frameworks. *International Journal of Mobile and Blended Learning*, *13*(1). https://doi.org/10.4018/IJMBL.202101xxxx

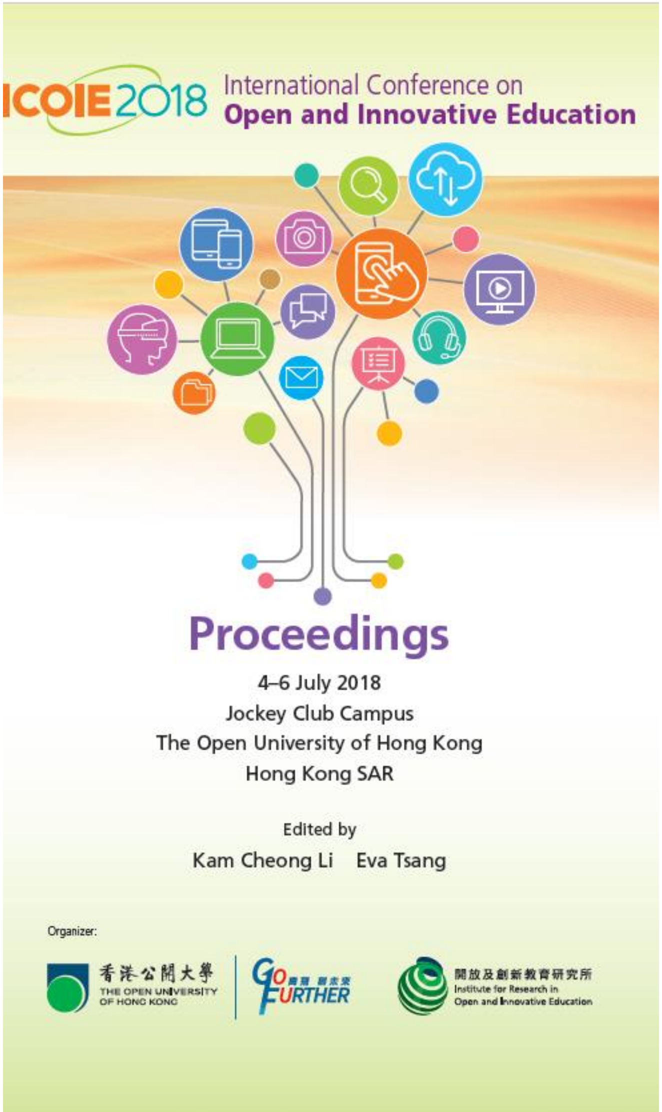
https://www.igi-global.com/journal/international-journal-mobile-blended-learning/1115#table-of-contents



6.3 Planning to Implement Change: Strategic Pillars to Lead Mobile Learning in the Secondary School Environment

Moya, S., & Camacho, M. (2018). Planning to Implement Change: Strategic Pillars to Lead Mobile Learning in the Secondary School Environment. *Conference: International Conference on Open and Innovative EducationAt: Hong Kong*, 205–221.

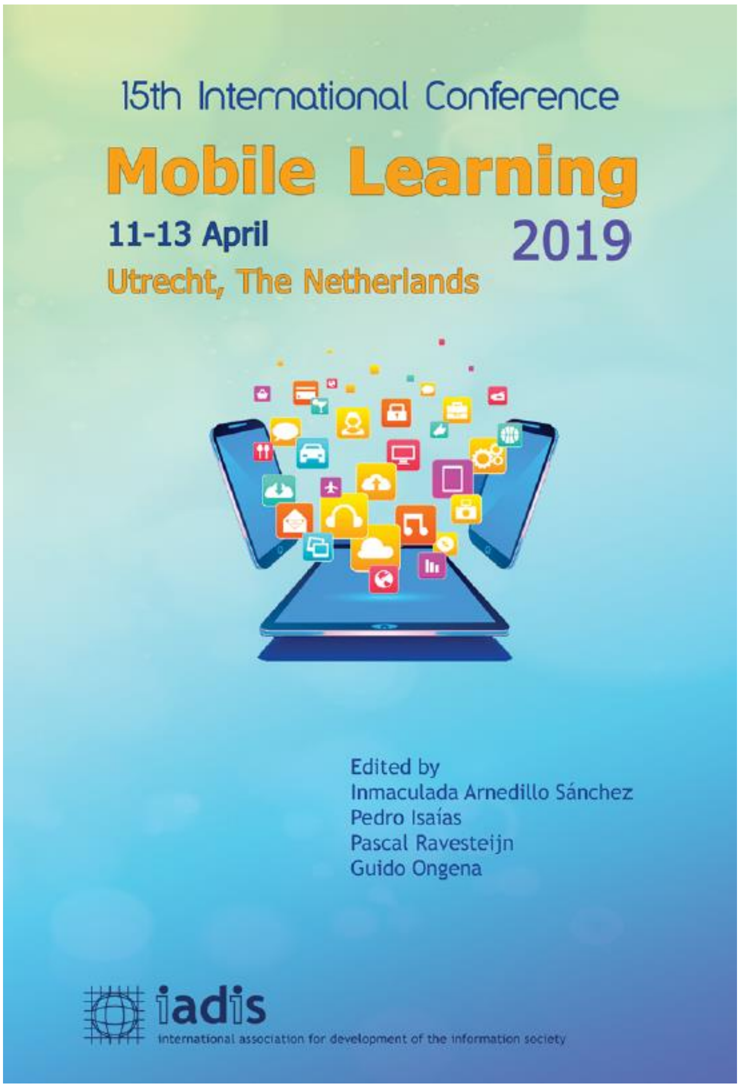
https://bit.ly/2keIkF8



6.4 What factors matter most for mobile learning adoption?

Moya, S., & Camacho, M. (2019). What factors matter most for mobile learning adoption? *Proceedings of the 15th International Conference on Mobile Learning 2019, ML 2019*. https://doi.org/10.33965/ml2019_201903l004

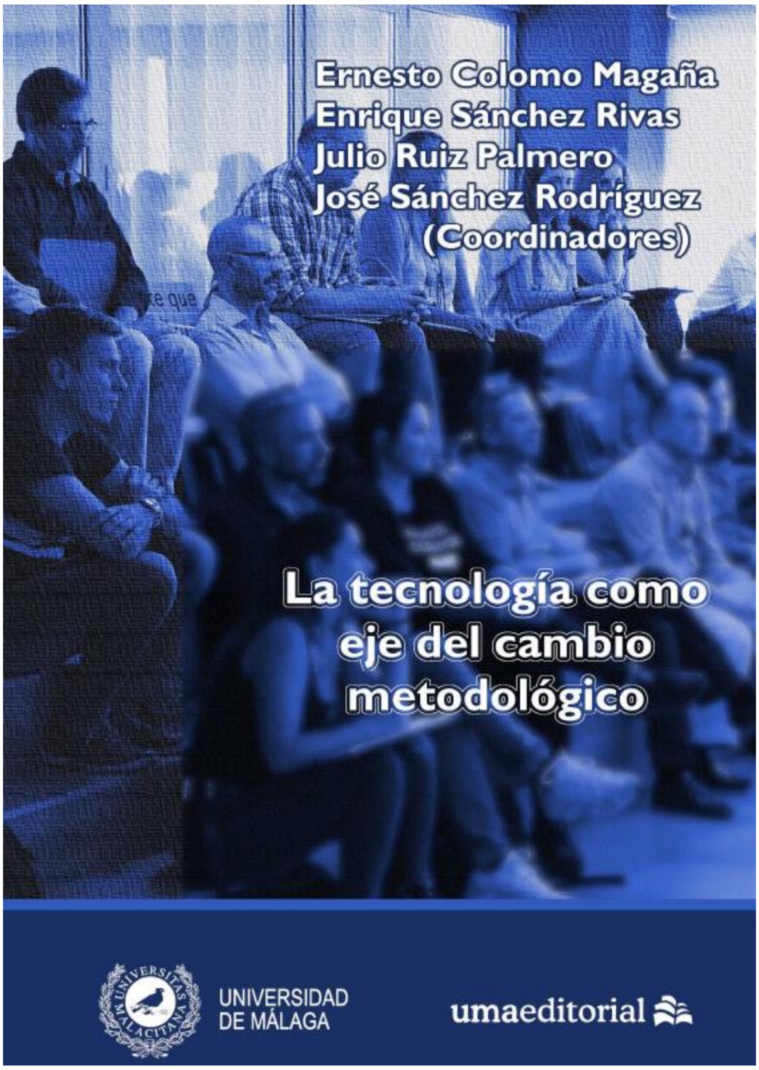
https://eric.ed.gov/?id=ED601100



6.5 Factores que afectan la adopción de mobile learning en Cataluña

Moya, S., & Camacho, M. (2020). Factores que afectan la adopción de mobile learning en Cataluña. In UMA editorial (Ed.), *XXIII Congreso Internacional Edutec* (pp. 783–786).

https://riuma.uma.es/xmlui/handle/10630/19862



6.6 Cuadro de mando para el seguimiento en la adopción del mobile learning en educación

Moya, S., Camacho, M., & Palau, R. (2020). Cuadro de mando para el seguimiento en la adopción del mobile learning en educación. In U. A. de Barcelona (Ed.), *VI Congreso Internacional EDO 'La nueva gestión del conocimiento'*.

https://edoserveis-uab.cat/congreso2020/organizacion/actas