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A Review of Research on Mobile Learning in Teacher Education

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ABSTRACT

Mobile devices have become attractive learning devices for education. While the majority of the existing research has focused primarily on the value of mobile learning for students, researchers have recently started exploring its potentials within teacher development. The present qualitative synthesis of quantitative and qualitative research aimed to address trends and gaps observed in the literature regarding the integration of mobile learning into teacher education. Six main findings emerged: (a) there is an increasing trend in integrating mobile learning in teacher education contexts; (b) theoretical and conceptual perspectives are scarcely reported; (c) variations exist in perceptions, attitudes and usage patterns; (d) engagement with mobile learning and devices is primarily reported as being beneficial; (e) challenges were scarcely reported; and (f) several pedagogical affordances support mobile learning integration into teacher education settings. These findings have been interpreted to determine their implications on the development of mobile learning experiences in teacher education, including programmatic directions for integration and study.

Keywords

Mobile learning, Teacher education, M-learning, Preservice, In-service

Introduction

Over the past two decades, technology devices have become mobile — portable and networked — to the point that they have become pervasive in everyday life. The use of mobile devices has become common among a wide range of age groups due to affordability and availability (Newhouse, Williams, & Pearson, 2006). Significant investments have been made to provide infrastructure, content, and resources related to the integration of mobile devices into learning environments (Johnson, Smith, Willis, Levine, & Haywood, 2011), and researchers have long had an interest in this evolving landscape (Kukulska-Hulme, Sharples, Milrad, Arnedillo-Sánchez, & Vavoula, 2009). However several limitations exist, such as lack of theoretical and pedagogical underpinnings, sustainable integration into formal educational contexts, and, particularly, lack of teacher support and training (Cochrane, 2012; Peng, Su, Chou, & Tsai, 2009).

Teacher support and teacher training have been the least explored topics in mobile learning research (Ekanayake & Wishart, 2014). Mobile learning is especially under-theorized in teacher education (Kearney & Maher, 2013), despite the need to inform teachers of the value of mobile technologies and how to integrate them effectively into their classes (Schuck, Aubusson, Kearney, & Burden, 2013). In their review of mobile learning projects conducted in Europe, Kukulska-Hulme et al. (2009) revealed that at the "European and individual state level, there appears to be little teacher development or training activity addressing mobile learning" (p. 14). Challenges related to teachers' adoption of mobile technologies have emerged from the fact that they are not effectively prepared to investigate the advantages or make informed decisions (Kukulska-Hulme et al., 2009; Schuck et al., 2013). Because of both the pressure to provide teachers with effective technology integration skills and the rapid growth of mobile technologies as learning devices, teacher education programs need to implement theoretically and pedagogically sound mobile learning initiatives (Newhouse et al., 2006).

This review aims to fill a gap in the current research on mobile learning. Previous literature reviews have synthesized trends and provided analysis of findings (Hwang & Tsai, 2011; Hung & Zhang, 2012), but no systematic research has been conducted on mobile learning and teacher education. This is the first review to initiate an evidence-based discussion on mobile learning and related emerging pedagogical directions in teacher education.

Mobile learning and theoretical perspectives

The diversity of the research on mobile learning has made it difficult to generate a single definition or to determine generally added benefits (Frohberg, Göth, & Schwabe, 2009; Sharples, Arnedillo-Sánchez, Milrad, & Vavoula, 2009). While it is typical for an emerging field to have varied definitions, the lack of conceptual frameworks and

robust theories has been frequently addressed as a concern in the literature (Peng et al., 2009). Definitions of mobile learning emphasize mobility (Sharples et al., 2009), access (Parsons & Ryu, 2006), immediacy (Kynäslahti, 2003), situativity (Cheon, Lee, Crooks, & Song, 2012), ubiquity (Kukulska-Hulme et al., 2009), convenience (Kynäslahti, 2003), and contextuality (Kearney, Schuck, Burden, & Aubusson, 2012). According to Sharples et al. (2009), mobile learning includes the characteristics of mobility in physical, conceptual, and social spaces. The "relationship between the context of learning and context of being" is unique to mobile learning, as learning may occur in independent, formal, or socialized contexts (Frohberg et al., 2009, p. 313).

The greatest added value of mobile learning vis-a-vis PC learning lies in the aspects that extend classroom interaction to other locations via communication networks. Recent advances such as imbedded sensors, cameras, motion detection, location awareness, social networks, web searching, and augmented reality present the potential to foster learning and engagement across multiple physical, conceptual, and social spaces, both indoors and out (Newhouse et al., 2006). Mobile learning enables teachers and learners ubiquitous and seamless access to information (Kukulska-Hulme et al., 2009; Seppälä & Alamäki, 2003), and convenience, expediency, and immediacy are valuable to teachers and enhance students' learning (Kynäslahti, 2003). These features provide opportunities for individualized, situated, collaborative, and informal learning without being limited to classroom contexts (Cheon et al., 2012). While portability and mobility have already made these devices attractive tools, developments such as geospatial technologies, search capabilities, image and video capture, and context awareness have further increased their versatility by promoting situated learning experiences and allowing exploration within authentic settings, particularly supporting inquiry-based learning (Martin & Ertzberger, 2013).

While the majority of research on mobile learning has focused primarily on students, recently teachers and researchers have started exploring the potentials of mobile learning and devices within teacher education. By synthesizing the literature on mobile learning and teacher education, this research aimed to address the trends and gaps observed in order to determine current implementation practices.

Research methods

Educational research syntheses demonstrate important interactions and connections from existing literature and offer conclusions or build theories for further research and practice (Minner, Levy, & Century, 2010). Given the methodological diversity of educational research on mobile learning in teacher education, this review is a qualitative synthesis of quantitative and qualitative research. Qualitative research syntheses can be defined as,"[S]ystematic efforts of synthesizing qualitative research" (Suri & Clarke, 2009, p. 401). This research synthesis departed from a strictly positivist, meta-analytic approach to syntheses, with its promotion of, "[T]ansparency of process to enhance accountability, credibility, and transferability of synthesis findings" (Suri & Clarke, 2009, p. 413) as suggested for research syntheses primarily qualitative in nature.

The synthesis followed three distinct phases: search and inclusion, individual study review, and cross-study comparison and analysis. Phase 1 involved searching for keywords "mobile learning" and "teacher education" or "mobile learning" and "teacher" or "mobile" and "teacher" in academic journals in the ERIC and Education Research Complete databases, and this search yielded 92 results. In the second round of search, the search terms "teacher education" and "mobile learning" were applied to Google Scholar and the following primary research journals: *Journal of Educational Technology and Society*, *Computers and Education*, *British Journal of Educational Technology*, *Journal of Computer Assisted Learning*, *Educational Technology Research and Development*, *Journal of Computing in Teacher Education*, *Journal of Technology and Teacher Education*, *Journal of Research on Technology in Education*, *Journal of Digital Learning in Teacher Education*. Moreover, references in each of the identified articles were checked for related work. As of August 2014, 237 new articles were thus identified from this search, resulting in a new total of 329 articles. The articles were organized and coded according to their context (e.g., preservice teacher education, in-service teacher education, professional development, K12 classrooms), and type (e.g., empirical, theoretical, case description, editorial, policy).

For the final tally of articles for the research synthesis, inclusion criteria were applied to ensure the articles included: (a) empirical research on mobile learning in preservice and in-service teacher education contexts across different disciplines (e.g., social studies, literacy, and math); (b) applications of mobile technologies (e.g., mobile phones,

smartphones, tablets) in a teacher education context; (c) in-service teacher, preservice teacher, or teacher educator participants; and (d) publication in a peer-reviewed journal, rather than a technical reports, project anecdote, or similar proceeding. Studies on preservice and in-service teachers' perceptions of mobile learning were also included to present the current landscape surrounding the use of these technologies as teaching tool. Because the aim was to investigate empirical research on mobile learning in teacher education contexts, these exclusion criteria significantly decreased the number of articles to 42. 5 more articles were also eliminated because they presented a theoretical or conceptual work on mobile learning and not empirical research. Two articles that lacked the descriptions of their research methodologies were included in the list because they provided anecdotal evidence regarding mobile learning and its implications in teacher education and helped to broaden the focus of this review.

Phase 2 included an analysis of the remaining 37 articles. The articles were subsequently examined and coded with notations in an analytic research synthesis table including the meta-categories of teacher education context, country context, subject domain, type, definition of mobile learning, reliability, validity and trustworthiness reports, mobile technologies used, outcomes in terms of teacher knowledge and practice, and pedagogical approaches. Notations related to methodology, such as the study's purpose, data sources, and participant information were included in the analytic table to foster comparisons among the studies (see Table 1). The salient aspects of the articles and their categories were evaluated with two research assistants as external reviewers who had research experiences in mobile learning and teacher education projects.

Phase 3 of the research included a comparison of the studies within the identified categories. The data were further investigated "to consider themes, shapes, and organization of research ideas present in the overall literature" (Opfer & Pedder, 2011, p. 383). Following themes emerged that captured variations and commonalities: Trends, perceptions, attitudes and usage patterns, benefits and challenges of mobile learning, and practices within teacher education contexts. The findings below report on these comparisons with conclusions representing the research synthesis and implications.

Table 1. An analysis of studies on mobile learning and teacher education (n = 37)

Study	Subject Domain	Subjects	Type	Method	Data sources	Reliability, validity, trustworthiness report	Technology used	Country context
Ekanayake & Wishart (2014)	Science	In-service teachers	Implementation	Case study	Observations via video, audio recording and field notes	*	Mobile phone	Sri Lanka
Husbye & Elsener (2013)	Literacy	Preservice teachers	Implementation	Case description	--		Tablet, smartphone, laptop	U.S.A.
Foulger et al. (2013)	Mix	Teacher educators	Survey	Interpretivist model of qualitative research	Questionnaire	*	Mobile device	U.S.A.
Aubusson, Schuck, & Burden (2009)	Mix	In-service teachers, teacher advisors and developers	Survey	Qualitative	Interview		Mobile phone	Cross country (Australia, UK)
Schuck et al. (2013)	Mix	Teacher educators	Implementation	Design-based research	Written materials, artifacts, discussions	*	Smartphone, iPod	Australia
Serin (2012)	Mix	Preservice teachers	Survey	Mixed methods	Questionnaire	*	Mobile technology	Turkish Republic of Northern Cyprus
Uzunboylu & Özdamlı (2011)	Mix	In-service teachers	Survey	Survey development	Questionnaire	*	M-learning technology	Turkish Republic of Northern Cyprus
Seppälä & Alamäki (2003)	Home Economics	Preservice teachers, supervising	Implementation	Case study	Interview		Smartphone	Finland

		teachers						
Cushing (2011)	Mix	Preservice teachers, supervising teachers, project leaders, support staff	Implementation	Case study	Interviews, observations, retention and achievement data, survey		Smartphone	UK
Thomas & O'Bannon (2013)	Mix	Preservice teachers	Survey	Qualitative descriptive research	Survey	*	Mobile phone	U.S.A.
Thomas, O'Bannon, & Bolton (2013).	Mix	In-service teachers	Survey	Survey	Survey	*	Mobile phone	U.S.A.
Şad & Göktaş (2013)	Mix	Preservice teachers	Survey	Survey	Survey	*	Mobile phone, laptop	Turkey
Kearney & Maher (2013)	Math	Preservice teachers	Implementation	Case Study	Journals, focus group interviews, artifacts		iPad	Australia
Newhouse et al. (2006)	Mix	Preservice teachers	Implementation	Mixed methods	Survey		Laptop	Australia
Chen (2010)	Mix	Preservice teachers	Implementation	Mixed methods	Survey		PDA	Taiwan
Mahruf, Shohel, & Power (2010)	English Language Teaching	In-service teachers	Implementation	Mixed methods	Survey, classroom observation, interviews		iPod	Bangladesh
Hashim (2014)	Mix	In-service teachers	Implementation	Quantitative	Survey	*	iPad	Malaysia
Shotsberger (2003)	Math	Preservice teachers	Implementation	Mixed methods	Survey, usage data		Handheld PC	U.S.A.
Hossain & Quinn (2013)	Math	Preservice teachers	Implementation	Mixed methods	Questionnaire		Smartphone	U.S.A.
İsmail, Azizan, & Azman (2013)	Information Technology	In-service teachers	Survey	Quantitative	Questionnaire	*	Mobile phone	Malaysia
Kommers (2009)	Mix	Preservice teachers	Implementation	Experimental	Survey		PDA	The Netherlands
Bates & Martin (2013)	Literacy	Literacy coaches	Implementation	Design based research	Interviews, blog, digital notes		iPad	U.S.A.
Valtonen, Havu-Nuutinen, Dillon, & Vesisenaho (2011)	Mix	Preservice teachers	Implementation	Case study	Students' lecture notes		Laptop	Finland
Ciampa (2014)	Literacy	In-service teachers	Survey	Case study	Interview, teacher blog, observation, ecological surveys		Tablet	Canada
Burton et al. (2011)	STEM	Preservice teachers	Implementation	Mixed methods	Pre-post test, cell phone attitude survey	*	Mobile phone	U.S.A.
Franklin, Sexton, Lu, & Ma (2007)	Mix	Preservice teachers	Implementation	Qualitative Case study	Weekly journals, pre-post survey of technology skills, classroom observation,		PDA	U.S.A.

					interviews			
McCaughtry & Dillon (2008)	Physical education	Preservice teachers	Implementation	Interpretative ethnographic	Fieldwork journals, observation, interviews	*	PDA	U.S.A.
Gado, Ferguson, & van't Hooft (2006)	Science	Preservice teachers	Implementation	Mixed methods	Interviews, student reflection reports, journals, observations of peer teaching, questionnaire	*	PDA	U.S.A.
O'Bannon & Thomas (2014)	Mix	In-service teachers	Survey	Quantitative	Survey	*	Mobile phone	U.S.A.
Looi, Sun, Seow, & Chia (2014)	Science	In-service teachers	Implementation	Qualitative	Classroom observations, field notes, audio, video transcripts	*	Mobile phone	Singapore
Järvelä, Näykki, Laru, & Luokkanen (2007)	Mix	Preservice teachers	Implementation	Design experiments	Observation, log files, interviews, questionnaire		Mobile phone, laptop	Finland
Crippen & Brooks (2000)	Science	Preservice teachers	Implementation	Case description	--		PDA	U.S.A.
Price et al. (2014)	Science	Preservice teachers	Implementation	Design based research	Observation, video, interviews		Smartphone	UK
Coens, Degryse, Senecaut, Cottyn, & Clarebout (2011)	Physical education	Preservice teachers	Implementation	Quantitative	Knowledge tests		iPod	Belgium
Hargis, Cavanaugh, Kamali, & Soto (2013)	Mix	Teacher educators	Survey	Mixed method	Interview, observations, survey	*	iPad	Abu Dhabi
Herro, Kiger, & Owens (2013)	Mix	Teacher educators	Implementation	Case description	--		iPod, iPad	U.S.A.
Kafyulilo (2014)	Mix	Preservice teachers In-service teachers	Survey	Mixed method	Questionnaires, interviews	*	Mobile phone	Tanzania

Findings

Several main findings emerged as a result of the research synthesis of the selected 37 articles on mobile learning and teacher education, outlined below in terms of trends, theoretical perspectives, perceptions, attitudes, and usage patterns, benefits, challenges, and teacher education contexts.

Trends in the mobile learning and teacher education literature

The articles examined were bound within the period, between 2000 and the first half of 2014, when research on emerging mobile technologies in education was burgeoning. As illustrated in Figure 1, in the last two years more than 50% of the articles from the period 2000-2014 have been published. Consistent with the widespread usage of

mobile tools, researchers and teacher educators have showed an increasing interest in the integration of mobile technologies into teacher education contexts. As shown in Table 1, almost 38% of the research on mobile learning was conducted in the U.S.A teacher education contexts followed by Australia (n = 3) and Finland (n = 3). It is especially noteworthy that more countries contributed to the mobile learning research in teacher education in recent years, such as Malaysia, Canada, Singapore, UK and Tanzania.

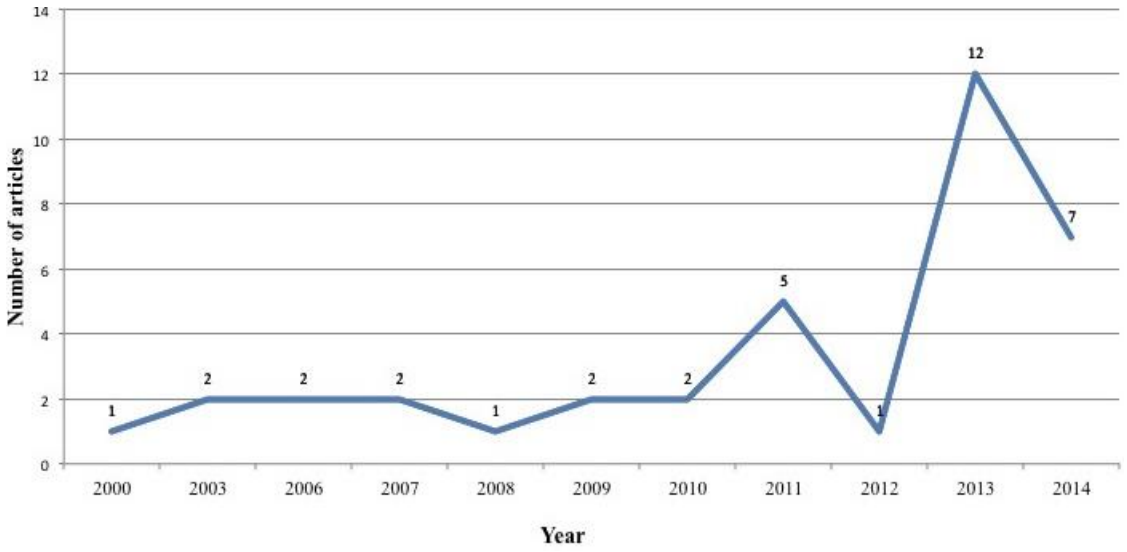

Figure 1. Publication trends from 2000 to 2014

The studies examined in this review used varied methodologies, with a majority being case studies or mixed method. Of the 37 studies, 21 were conducted within preservice teacher education contexts, 10 within in-service teacher education context, four within teacher educators' contexts, one in both preservice and in-service teacher education contexts, and one in a coaching context. As shown in Figure 2, the majority of the studies crossed content areas, except five studies on science, three on math, three on literacy, two on physical education, one on information technology, one on STEM teacher education, one on English language teaching, and one on home economics teacher education.

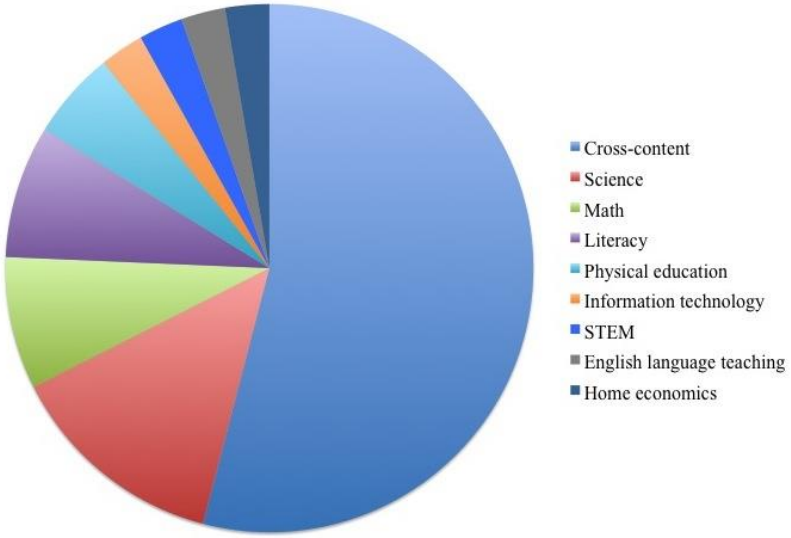

Figure 2. Distribution of studies by subject domain

The articles' research purposes were classified according to two types: (1) survey-dominant or (2) implementation-dominant. More than half of the studies were identified as implementation-dominant (n = 25) that focused on the application of a mobile learning system, program, project or course and presentation of cases and strategies of mobile learning in teacher education contexts, while others were identified as survey-dominant (n = 12) that mainly focused

on surveying participants' usage, perceptions, or attitudes on of mobile tools within their contexts. Data sources included questionnaires, interviews, blogs, recordings, observations, journals, artifacts, usage data, and audio and video transcripts. Among 37 studies reviewed, only 17 articles reported the validity, reliability or trustworthiness of their measures. Mobile phones (e.g. smartphones, cell phones) were the most common mobile devices used in teacher education contexts (42.5%), followed by tablets (e.g., iPads) (17.5%), PDAs/Handheld PCs (17.5%), iPods (10%), and laptops (12.5%). The type of mobile device used over time, particularly in 2013 and 2014, mostly included mobile phones/smartphones and tablets. The large number of implementation studies illustrates teacher educators' interest in the application of mobile learning systems in their contexts. With mobile technologies being more ubiquitous, it is predicted that teacher educators will continue to explore the pedagogical affordances of new mobile technologies in their contexts.

Scant report of theoretical and conceptual perspectives

Analysis revealed scant reports of theoretical perspectives integrated into mobile learning research in teacher education. Out of 37 studies, only five reported using a theoretical or pedagogical framework to design or implement the research. Kearney et al. (2012), using m-learning and socio-cultural theory, identified three distinctive features of m-learning: authenticity, collaboration, and personalization. These features were later tested within m-learning projects conducted in teacher education communities (Kearney & Maher, 2013). Kearney and Maher (2013) emphasized the importance of putting pedagogy at the center of mobile learning rather than technology in order to examine its advantages for supporting learning. In order to help teacher educators understand mobile technology integration, Schuck et al. (2013) combined the concept of a professional learning community (PLC) with a community of practice (CoP) and coined the term mobagogy to "capture dual interests of the community in mobile technologies and pedagogy" (p. 4). The purpose of this approach was to help teacher educators explore mobile learning through their interactions with colleagues in the CoP. Other theoretical perspectives included experiential self-regulated learning (Järvelä et al., 2007), motivation theory (Ciampa, 2014), and cognitive development theory (McCaughtry & Dillon, 2008). Järvelä et al. (2007) used self-regulated learning theory "as a theoretical framework to develop those learning activities that give potential to individual and collaborative learning so that it stimulates active minds and interactions on individual and social levels" (p. 72). Ciampa (2014) used motivation theory to understand how motivational elements could help design of learning systems with mobile tools, and McCaughtry and Dillon (2008) used cognitive development theory to examine changes in teachers' thinking as they integrate new technologies in their contexts.

The literature investigated herein lacks new approaches, models and frameworks for teacher education programs designed specifically to develop mobile learning pedagogies. Mobile tools have the potential to enhance mobility in classrooms; fundamentally changing the way classrooms are organized within teacher education programs. However, the literature needs to establish pedagogical and theoretical models that can guide teacher educators in designing mobile learning experiences for preservice and in-service teachers. These models need to present strategies for equipping teachers and teacher educators with methods for integrating mobile learning into classrooms as well as supporting professional learning with mobile tools. Similarly, systematic and programmatic efforts are missing that explore the integration of mobile learning into preservice teacher education curricula.

Varied perceptions, attitudes and usage patterns

Survey studies conducted with preservice teachers revealed varied results regarding perceptions, attitudes and usage about the use of mobile devices for learning and teaching. The outcomes were diverse depending on the variables in teacher education contexts such as the availability and accessibility of technologies, resources, country infrastructure, and motivation of teacher education programs. Researchers found that an increasing number of preservice teachers were accessing resources on mobile devices (Hossain & Quinn, 2013; Shotsberger, 2003). However, Serin's (2012) investigation of 355 prospective teachers revealed low levels of perceptions regarding mobile learning. Similarly, Thomas and O'Bannon's (2013) survey study with preservice teachers revealed that perceived benefits of cell phone usage in the classrooms were limited. Şad and Göktaş's (2013) survey study reported that preservice teachers favored laptops over mobile phones lacking smartphone features. McCaughtry & Dillon (2008) reported a shift in preservice teachers' perceptions following initial skepticism towards integration of mobile devices (PALMS) in teacher

education, and Gado et al. (2006) reported a positive change in preservice teachers' self-efficacy and attitudes towards technologies after classroom exposure to handheld computers.

Survey research conducted with in-service teachers also reported varied results. For example, Uzunboylu and Özdamlı's (2011) investigation of the m-learning perception scale with 467 teachers in the Turkish Republic of Northern Cyprus indicated above medium levels of perception regarding mobile learning. However, another survey conducted with 38 Malaysian in-service teachers revealed that the majority did not consider mobile phones learning and teaching tools within their schools. On the other hand, Thomas, O'Bannon and Bolton's (2013) survey study of 79 teachers found that the majority supported the use of cell phones in the classroom. O'Bannon & Thomas's (2014) survey on the use of mobile phones in the classroom with 1095 teachers in the southeastern United States revealed that teachers older than 50 were less supportive compared to younger groups.

This review revealed scant report of validity and reliability issues in the survey studies as well as information on piloting the instruments. Only seven studies provided some explanation of a pilot test conducted on their data collection instruments (e.g., Hashim , 2014; İsmail, Azizan, & Azman, 2013; O'Bannon & Thomas, 2014; Şad & Göktaş, 2013; Thomas & O'Bannon, 2013; Thomas, O'Bannon, & Bolton, 2013; Uzunboylu & Özdamlı, 2011). Limited information on these issues makes it difficult to compare the results of these questionnaires. Research in this area would further benefit from discussion on the trustworthiness of the methods and more detailed information about the context used to investigate mobile learning in teacher education.

Mobile learning is reported as mainly beneficial

The literature on mobile learning and teacher education generally considered mobile learning a beneficial approach in extending teachers' learning experiences and enhancing their mobile technology integration skills. The literature identified several motivating factors for the integration of mobile learning into preservice teacher education settings, such as modeling mobile pedagogies (Burton et al., 2011; Cushing, 2011; Foulger et al., 2013; Franklin et al., 2007; Gado et al., 2006; Herro et al., 2013; McCaughtry & Dillon, 2008), deeper explorations of content areas (Gado et al., 2006; Husbye & Elsener, 2013; Kearney & Maher, 2013; Mahruf et al., 2010; McCaughtry & Dillon, 2008; Shotsberger, 2003; Burton et al., 2011), enhancing preservice teachers' mobility (Coens et al., 2011; Husbye & Elsener, 2013), connecting preservice teachers with a larger community (Cushing, 2011; Husbye & Elsener, 2013; Kearney & Maher, 2013), providing preservice teachers with personalized learning experiences (Kommers, 2009), enhancing social interaction (Järvelä et al., 2007; McCaughtry & Dillon, 2008; Valtonen et al., 2011), presenting alternative assessment techniques (Chen, 2010), and promoting collaborative knowledge construction (Järvelä et al., 2007).

Studies that investigated the use of mobile learning or mobile tools in teacher education contexts mainly reported positive contributions to the outcomes investigated. Mobile tools were found to have potential for helping preservice teachers understand and develop new literacies (Husbye & Elsener, 2013), explore mathematics in the real world (Kearney & Maher, 2013; Shotsberger, 2003), conduct scientific investigations (Gado et al., 2006), engage in rich language learning contexts (Mahruf et al., 2010); and explore real world physical education (McCaughtry & Dillon, 2008). These tools can fundamentally change the way classrooms are organized within teacher education programs by increasing mobility (Price et al., 2014). Another advantage reported was features that connect preservice teachers to their colleagues, enhance professional learning through collaboration, and facilitate mentoring processes (Cushing, 2011; Husbye & Elsener, 2013; Kearney & Maher, 2013). Mobile tools could help build closer relationships as well as more personalized learning experiences for teacher candidates as needs change over time (Crippen & Brooks, 2000; Herro et al., 2013; Kommers, 2009).

Advantages in integrating mobile learning into in-service teacher education contexts included promoting reflection-in-action as a critical component of professional learning (Aubusson et al., 2009); providing timely access to resources (Shotsberger, 2003); allowing participation in knowledge production and sharing regarding teaching practices (Aubusson et al., 2009); and capturing, reflecting upon, and sharing experiences (Aubusson et al., 2009). In addition to conducting professional development via mobile tools, researchers also investigated the impact of such programs on teachers' inclusion of these technologies in their classrooms. Looi et al. (2014) investigated a mobilized 5E science curriculum co-designed by the teachers and observed that their pedagogical orientations affected both their technology integration and their relationships with students.

Advantages of mobile learning for teacher educators were also addressed in the literature. Husbye & Elsener (2013) found that after being exposed to teacher educators' mobile device integration, preservice teachers began to utilize such tools in their own practices. By encouraging mobility, the teacher educators' role shifted from a content provider at the center of instruction to a facilitator, engaging preservice teachers as they collaboratively constructed meanings around content (Husbye & Elsener, 2013).

Scant report of challenges

This research synthesis revealed that extant studies have mainly emphasized the benefits of mobile learning integration into teacher education without detailing its drawbacks. According to the results of Foulger et al.'s (2013) survey in the United States, teacher educators are in the process of investigating this innovation further, as "mobile technology in teacher preparation is uncharted territory and they are taking a certain level of risk by exploring its possibilities" (Foulger et al., 2013, p. 22). A number of challenges related to mobile technology integration were reported, including ethical issues, lack of support, accessibility and technical limitations, insufficient experience, mobile phone bans in schools, and curriculum adaptations.

Teachers, while accepting the benefits of mobile learning, raised concerns about potential ethical issues such as cyber-bullying, privacy, archiving and record keeping, sharing classroom experiences and artifacts, parental and student informed consent, and e-safety (Aubusson et al., 2009; Cushing, 2011). Teacher educators, by encouraging ethical use of these devices as learning tools to enhance rather than disrupt class flow, could model practices for preservice and in-service teachers (Cushing, 2011).

Another challenge noted was the need for ongoing technical and material support (Mahruf et al., 2010); teachers received minimal technological and pedagogical assistance from higher education institutions with regard to effective implementation of mobile learning in teacher education (Foulger et al., 2013; Cushing, 2011). Lack of support in terms of policies could also lower teachers' perceptions regarding the use of mobile devices as learning tools (Ismail et al., 2013), as well as insufficient funding or professional development support (Herro et al., 2013).

The accessibility of mobile devices is another challenge. If mobile learning is to be implemented successfully, all preservice and in-service teachers must have access to mobile devices as part of their training (Cushing, 2011; Gado et al., 2006; McCaughtry & Dillon, 2008). Teacher educators noted that mobile devices should be provided to preservice teachers to ensure digital equity (Husbye & Elsener, 2013). Additional technical limitations included low bandwidth on wireless networks, small screen size, insufficient memory capacities, and limited software (Franklin et al., 2007; Newhouse et al., 2006).

Lack of expertise integrating mobile technologies was also a challenge to effective integration of mobile learning into teacher education (Foulger et al., 2013; Valtonen et al., 2011). Research has suggested that mobile technologies need to be used as tools for enhancing preservice teachers' experiences, not as an add-on incorporating technology for its own sake (Husbye & Elsener, 2013). Mobile learning must be meaningfully integrated into all teacher education courses, not only technology courses (Foulger et al., 2013). Limited, unclear best practices regarding preparing teachers for the integration of mobile devices is a definite barrier (Herro et al., 2013).

One particularly critical challenge noted with regard to integration of mobile learning into in-service teacher education is the prohibition of cell phone usage within schools, which may affect teachers' attitudes regarding mobile learning in their classes or prevent them from making any efforts to that end (Ismail et al., 2013).

If mobile tools are to be integrated effectively into classrooms, curricular issues also need to be taken into consideration. For example, Looi et al. (2014) found limited research on the investigation of teachers' curricular-based implementations of mobile learning and devices. Price et al. (2014) further noted that while preservice teachers' ideas about integration into science classes could be supported by teacher education programs, their implementation into a non-existing or incompatible curriculum (e.g., geospatial integration in science) is obviously an obstacle.

While benefits were commonly reported in the literature, the studies lacked investigations on the drawbacks and challenges of mobile learning in teacher education. For example, the discussions on the issues regarding ethical use,

accessibility, and privacy were limited. It is thus crucial to conduct longitudinal research to determine the impact of sustained mobile learning initiatives in teacher education programs and critical success factors as well as challenges.

Mobile learning practices within teacher education contexts

The analysis of mobile learning practices within the studies revealed approaches with different goals based on audience. Three groups participated in the studies: preservice teachers, in-service teachers, and teacher educators.

Integrating mobile learning into preservice teacher education

Preservice teacher education programs and courses were the most common research contexts in the literature (e.g., Husbye & Elsener, 2013). Additionally, studies were conducted in the context of projects that included preservice teachers as participants of the studies (e.g., Schuck et al., 2013) and postgraduate teacher education certification programs (e.g., Price et al., 2014). The research synthesis revealed many pedagogical advantages of mobile learning in preservice teacher education: connectivity and collaboration, flipped classroom models, mobility within the physical space of the classroom, backchannel conversations, engaging with content on mobile devices, mobile learning in student teaching, performance evaluation, and participation in PLCs.

Mobile tools have capabilities of capturing real time information and integrating connectivity and collaboration into class activities. For example, Husbye and Elsener (2013) integrated mobile phones into early childhood literacy courses using QR codes to index videos of children reading to help preservice teachers move at their own pace. Mobile devices' connection capabilities also provided opportunities to share preservice teachers' products (e.g., teaching videos) on the web (Husbye & Elsener, 2013; Schuck et al., 2013). Similarly, Järvelä et al. (2007) used a mobile mind map tool to co-regulate preservice teachers' collaborative knowledge construction, as mobile devices "supported externalization of knowledge representations in individual and collaborative levels" (p. 71).

Flipped classrooms have recently been used as form of blended learning in which students learn course content on the web via video, audio, or text and use class time to engage in activities and get individual guidance. In teacher education courses, mobile devices helped establish flipped classrooms. For example, Husbye and Elsener (2013) asked preservice teachers to access materials (e.g., video podcasts) before class and engage in hands-on activity during class.

Mobile devices allow for mobility within and beyond the classroom's physical spaces. Another example shared by Husbye and Elsener (2013) was digital gallery walks, where students accessed web resources linked to QR codes on posters in class. Other examples included podcasts in contexts such as botanical gardens (Schuck et al., 2013) and capturing real life math phenomena (Kearney & Maher, 2013). Burton et al. (2011) implemented an augmented reality (AR) mobile game to enhance preservice teachers' self-efficacy and attitudes towards integrating AR pedagogies in future STEM classrooms. Following the participatory design approach, Price et al. (2014) designed the GeoSciTeach smartphone application to support preservice science teachers' awareness of the integration of geospatial ideas into science. Mobility, combined with other emerging features such as augmented reality and context awareness, helped facilitate contextualized and situated learning experiences.

The timely communication afforded by mobile devices could transform a class conversation from one-to-many to many-to-many and increase students' engagement via backchannel conversations. Teacher educators integrated mobile devices into courses where preservice teachers shared their understanding of content and participated in conversation online. Husbye and Elsener (2013), for example, used class-specific hashtags on Twitter, where students discussed class activities, commented on classroom experiences, and shared resources for best teaching practices. Similarly, Valtonen et al. (2011) used mobile devices in teacher education courses to enable students to capture and share lecture notes via social software, while Järvelä et al. (2007) used a mobile lecture interaction tool to enhance participation during lectures. Finally, Schuck et al. (2013) conducted activities where preservice teachers voted through text messages or "quick response" voting applications.

Preservice teachers also engaged with content on mobile devices. One group created digital narratives by capturing and editing videos, sharing them at a mobile phone film festival (Schuck et al., 2013). A science methods course

included the use of handhelds to engage preservice teachers in scientific inquiry to develop their understanding of science and math concepts (Gado et al., 2006). Preservice teachers also used mobile devices to organize their work and access reference tools such as dictionaries or the periodic table (Franklin et al., 2007).

Due to the potential for enhancement, researchers have investigated the integration of mobile devices into student teaching experiences. Preservice teachers, mentors, and teacher educators can easily connect via mobile tools to share feedback (Crippen & Brooks, 2000; Cushing, 2011; Foulger et al., 2013; Kommers, 2009; Schuck et al., 2013; Seppälä & Alamäki, 2003). Examples include microblogging (Schuck et al., 2013); virtual training (Seppälä & Alamäki, 2003); connecting mentors, project leaders, and preservice teachers via smartphones (Cushing, 2011) and PDAs (McCaughtry & Dillon, 2008); submitting school observation forms and weekly e-journals (Crippen & Brooks, 2000; Shotsberger, 2003); designing lesson plans with mobile device integration (Foulger et al., 2013); and real-time coaching (Kommers, 2009).

Finally, mobile devices allow preservice and in-service teachers to evaluate their own and their peers' learning quickly and efficiently. Chen (2010) developed a Mobile Assessment Participation System (MAPS) that aimed to facilitate the assessment of preservice teachers' self, peer, and group performances both synchronously and asynchronously. Preservice teachers also participated in PLCs on mobile devices, where they expanded on conversations and improved their understandings (Schuck et al., 2013). Mobile devices encouraged dialogues and communication between preservice teachers and practicum supervisors as well as teacher educators (Seppälä & Alamäki, 2003) and were used for synchronous coaching in school-based practicums, where preservice teachers received immediate, "on the job" feedback (Kommers, 2009).

Mobile learning with in-service teachers

Among 11 studies that investigated in-service teachers, only four of them implemented professional development programs on mobile learning, while others focused on surveying teachers' perceptions and attitudes towards mobile devices and mobile learning. Mobile learning research conducted within in-service teacher education contexts focused on their experiences using mobile technologies for their own learning (Aubusson et al., 2009; Hashim, 2014), the impact of mobile learning professional development programs on effective integration of mobile devices into classrooms (Ekanayake & Wishart, 2014; Mahruf et al., 2010), and perceptions regarding the use of mobile devices (Aubusson et al., 2009; Ciampa, 2014; Uzunboylu & Özdamlı, 2011).

Mobile learning holds promises for creating mobile, collaborative, contextualized, customized, and personalized learning opportunities for teachers. Aubusson et al.'s (2009) interviews with eight teachers, teacher developers, and teacher advisors in Australia and the UK revealed that educators considered mobile technology as beneficial for enhancing on the job learning. Uzunboylu and Özdamlı's (2011) mobile learning perception scale conducted revealed in-service teachers' (n = 467) positive perceptions toward m-learning. Another survey with in-service teachers revealed that iPads helped them access learning materials, collaborate in online forums, and access email. Ciampa's (2014) case study of teachers' perceptions on how mobile devices motivated students revealed the "six key aspects of successful (mobile) learning systems as challenge, control, curiosity, recognition, cooperation and competition" (p. 92).

To equip in-service teachers with the skills for effective integration of mobile devices, researchers conducted professional development programs and assessed their effectiveness. Such programs included the design of a series of workshops for secondary science teachers (Ekanayake & Wishart, 2014) and mobile access to development resources for English teachers (Mahruf et al., 2010). Ekanayake and Wishart's (2014) analysis of paper-based materials and audio and video recordings revealed that their workshops increased awareness of and response toward the potential benefits of science teaching and learning with mobile phones, helped develop pedagogical actions, and encouraged sharing knowledge related to technology integration. In another project, teachers watched and listened to material on iPods and other mobile devices (Mahruf et al., 2010). Interviews with participants revealed that accessing professional development resources via mobile devices helped them engage in new settings and develop pedagogical knowledge and English-language proficiency.

With the recent emphasis on using mobile technologies in education, the need has emerged to prepare teachers with effective classroom technology integration skills. Looi et al.'s (2014) unique study included teachers in the

curriculum design team and observed their mobile lesson enactment in classroom contexts. Similar programs for teacher development that follow situated, reflective, and authentic models hold promises for supporting teachers' learning of mobile technology integration.

Mobile learning with teacher educators

With the widespread use of mobile devices, teacher educators are expected to show more interest in testing the strategies for implementing mobile devices in their courses and professional development programs. Methods for preparing teacher educators for mobile learning included PLCs (Schuck et al., 2013) and literacy coaching practices (Bates & Martin, 2013). Using design-based research, Schuck et al. (2013) employed a PLC to support teacher educators in understanding advantages of mobile learning within teacher education and model good practices to preservice teachers. Their results revealed the need for distinction between mobile learning and mobile usage, as well as the necessity for exploring the pedagogical potentials of mobile technologies (Schuck et al., 2013). In another study, tablets were integrated into literacy coaching practices and classroom observations (Bates & Martin, 2013). Hargis et al. (2013) conducted observations, interviews, and surveys with faculty members who received training on iPads and found that iPads supported student-centered teaching. In another study, teacher educators collaboratively redesigned their coursework to emphasize "(a) assessing the value of mobiles in instruction, (b) pedagogical approaches, (c) content creation, (d) evaluation of apps, and (e) learner impact" (Herro et al., 2013, p. 35).

While faculty development is considered critical in adopting mobile learning practices in teacher education, only a limited number of studies examined teacher educators' practice and training about mobile learning. Teacher education programs can initiate mobile learning systems in collaboration with K-12 schools by implementing "visionary leadership, professional development, scalable pilot programs, and adequate resources" (Herro et al., 2013, p. 36).

Overall, this review captured the methods for integrating mobile learning into teacher education contexts. Mobile in teacher education contexts aimed to (a) teach teachers how to integrate mobile tools into their classrooms, and to (b) enhance teacher learning with mobile learning. Figure 3 summarizes these methods.

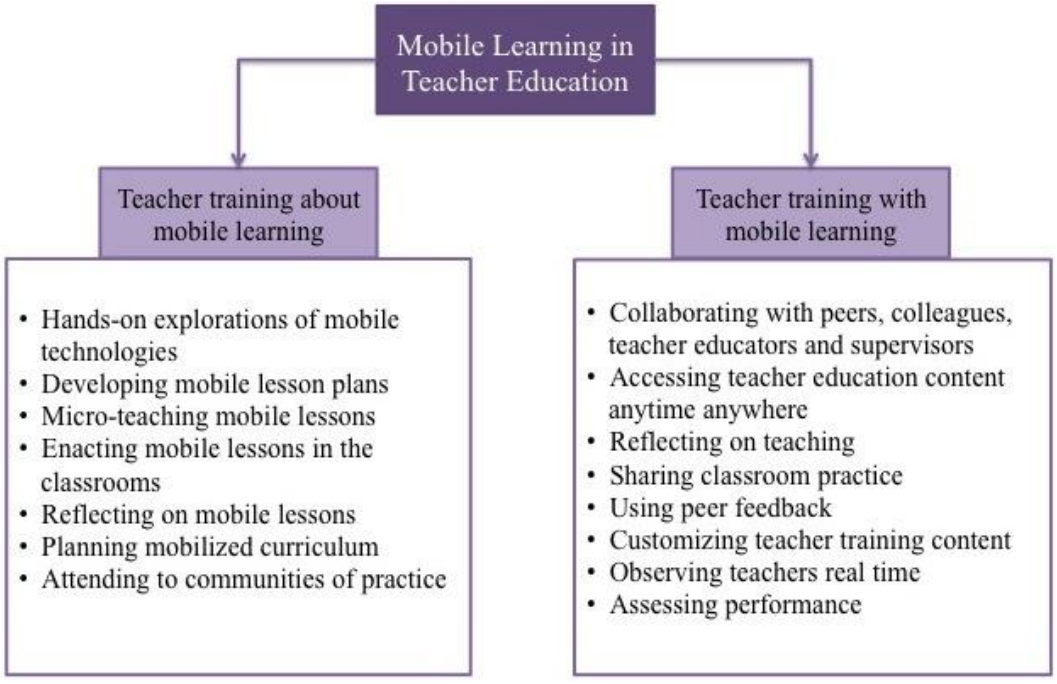

Figure 3. Methods for integrating mobile learning into teacher education

Conclusions

This systematic review of 37 articles on mobile learning and teacher education is timely in light of growing interest in mobile learning and a lack of syntheses in the context of teacher education. Findings are drawn as well as the approaches and strategies for implementing mobile learning and mobile tools in different teacher education contexts. First, the review revealed that the number of articles published has significantly increased over the last five years, with contributions from researchers around the world. This trend is consistent with other review findings on mobile learning (e.g., Hwang and Tsai, 2011; Wu et al., 2012). Second, there was a scant report of theoretical and conceptual perspectives. Third, survey studies revealed that perceptions, attitudes and usage patterns among teachers varied. Fourth, mobile learning was reported as mainly beneficial in teacher education contexts. Fifth, while there are notable exceptions, challenges or issues to integrate a mobile learning component in teacher education programs and curriculum were duly noted. Finally, several pedagogical affordances support mobile learning integration into teacher education settings. As educators begin to understand the potential of mobile learning in education, the role of teachers and teacher educators in integrating mobile devices becomes essential in addressing students' learning needs across several disciplines. This study presents findings and recommendations to help researchers, teacher educators, and policy makers develop research-informed guidelines and theoretical models to suggest methods on how to integrate mobile learning into teacher education.

Recommendations for future research and practice

This systematic review revealed a number of critical recommendations for those who plan to investigate the advantages of mobile learning for preservice and in-service teachers and integrating these technologies into teacher education contexts.

Transforming teacher education practices with theoretically sound approaches

Teacher educators need to go beyond the tools' potential to explore pedagogical benefits of mobile learning within their own content areas. This change will help preservice and in-service teachers realize the pedagogical advantages of mobile learning that may shift their perspectives toward the integration of mobile devices into their teaching environments. While a number of studies presented the benefits of using mobile devices within field experiences, more research is needed to understand its unique applications as well as its impact on mentor teachers', preservice teachers', and teacher educators' successful implementation of school-based practicums. To understand the sustained effect of mobile learning initiatives in teacher education programs, teacher educators and researchers also need to conduct longitudinal studies observing classrooms over time as well as enacting pedagogical approaches to mobile devices within actual classroom settings (Price et al., 2014).

Investigating additional strategies for mobile learning integration and expanding data corpus on mobile learning

Further research needs to investigate how different types of mobile learning projects, time requirements, and site contexts have an impact in the way teachers develop outcomes (e.g., content knowledge, pedagogical skills) and how different types of reflection, observation, design, planning, engagement, and assessment activities effect these outcomes. Based on this synthesis, it is also recommended that interested researchers expand the data corpus on mobile learning and establish its relationship to desired teacher outcomes, such as technological pedagogical content knowledge (TPACK) within mobile learning contexts and address issues endemic to teacher development and education in the teacher preparation phase.

Using varied research methodologies with diverse and larger samples and reports on trustworthiness

The majority of the research conducted on mobile learning and teacher education presents best practices and case studies conducted within contexts with limited scope and small sample size. While these best practices reveal critical findings, future empirical research must follow other methodological routes such as design-based research to develop

theories within practice and ethnography to understand how mobile learning interacts with social and cultural dynamics in teacher education contexts. The field also calls for studies with diverse and larger samples with rich descriptions of context and trustworthiness to make the findings transferable.

Developing new models for teachers' professional development using mobile learning

Research on mobile learning and teacher education technology has mostly investigated teachers learning about mobile technologies rather than learning with them. While a limited number of studies have looked at learning with mobile devices (Aubusson et al., 2009), more research is needed to understand how teachers and teacher educators' professional development can be supported with mobile learning. Additional research may also consider how the immersion of teacher educators into CoPs or PLCs helps them engage in a professional conversation about the integration of mobile learning within teacher education contexts, such as sharing stories and best practices, engaging in collaborative resource creation, and helping each other through a mentor or peer support system (Herro et al., 2013).

A systemic investigation of mobile learning in preservice teacher education

Greater insight into research on mobile learning in specific teacher education contexts has potential to support more system-wide adoptions of mobile learning, where more research is needed. While the research on preservice teacher education and mobile learning mainly included the investigation of mobile learning as an approach within individual teacher education courses, further research continues to be needed on the systemic investigations of mobile learning within entire teacher education programs. Different ways for mobile learning integration into teacher education can be examined, such as the infusion in practica, special courses (e.g., methods or classroom management), and throughout the teacher education program. Understanding the potential impact of mobile learning that is integrated into the entire teacher education programs and associated challenges and benefits are critical to gaining greater insight into the purposes of various phases of teacher education and the role of mobile learning in each.

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