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Jenni Rikala

Designing a Mobile Learning Framework for a Formal Educational Context

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ABSTRACT

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This research will focus on mobile learning in a Finnish formal educational context. While a variety of definitions of the term mobile learning has been suggested, in this study mobile learning refers to a teaching and learning method that utilizes mobile devices to (a) extend traditional teaching and learning and (b) sustain high levels of student engagement with rich connections to other people and resources across different contexts. Recently, mobile learning has aroused interest worldwide. However, the theoretical and practical basis of mobile learning is still somewhat fragmented. Therefore, the purpose of this study is to promote mobile learning theory and practice by designing a mobile learning framework. Three design cycles were conducted. During design cycle one, an initial version of the framework was developed based on the literature. The second design cycle included four case studies and advanced the initial version of the framework. The third design cycle included an online survey and deepened the understanding of factors that influence mobile learning in a formal educational context. Based on the three design cycles and the literature, a mobile learning framework is suggested. The framework clarifies the core aspects of mobile learning, as well as those aspects' interrelationships and other important factors that affect the pedagogically sustainable use of mobile devices in the educational context. The framework particularly highlights pedagogy, context, learner, device, and social interaction. The study also indicates that mobile learning requires preparation, competent teachers, a sufficient information and communication technology (ICT) infrastructure, and support. The study emphasizes that even though mobile devices are increasingly utilized in the educational context not all the potential that mobile devices offer has been realized as assumed.

Keywords: mobile learning, mobile learning framework, design-based research, education, information and communication technology (ICT)

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> If we knew what it was we were doing, it would not be called research, would it?
> - Albert Einstein –

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1 INTRODUCTION

This study provides insights into mobile learning in a Finnish formal educational context. The objective of the study is to promote mobile learning theory and practice by developing a mobile learning framework and guidelines for successful mobile learning integration. In this study, the term mobile learning refers to a teaching and learning method that incorporates mobile devices to extend traditional teaching and learning and to sustain high levels of student engagement with rich connections to other people and resources across different contexts. This study is timely as mobile devices (i.e., compact handheld devices like tablets, smartphones, personal digital assistants, navigation tools, laptop computers, electronic readers, media players, digital cameras, and game consoles) have become increasingly popular as well as an integral part of people's everyday life.

The availability of contemporary mobile devices has marked a turning point for the rates of mobile device usage. In 2013, vendors shipped more than one billion smartphones worldwide (International Data Corporation 2014) and in 2014, the global mobile penetration rate reached 95% (Ericsson Mobility Report 2014). Ericsson's Mobility Report (2014) estimated that 90% of the world's population would have a mobile phone by 2020. Tablet device shipments are expected to surpass personal computer shipments by the end of 2015 (International Data Corporation 2013). As a consequence of this rapid diffusion of mobile technologies, the ways in which people interact, communicate, and work have changed (Lam, Yau & Cheung 2010, 306). Remarkably, even some children under the age of 12 months are already playing with mobile devices (Suoninen 2010, 9–10). Mobile technologies have altered our societies and the way we live in many respects.

These changes in the environment within which people live also demand that individuals and groups learn in order to manage life and its changes (Jarvis 2010, 37). Thus, for most individuals, learning has something to do with managing life and its changes. However, learning can also refer to the outcomes of the learning process (i.e., what has been learned or the change that has taken place). On the other hand, the term learning can also refer to the mental processes that lead to changes or outcomes in knowledge, behaviors, skills, attitudes, or values. The term learning can also refer to the interaction processes between people and their learning material. (Illeris 2007, 2–3.) Hence, the term learning is broad and has diverse meanings. In this study, learning is primarily seen as acquiring knowledge and skills through actions or interactions that can be mediated through mobile devices.

Technological, social, and cultural changes have transformed the meaning and significance of learning even further (Traxler 2009b, 7). Technologies have made several new learning approaches and methods possible. One example is electronic learning, where computers and technology are used to promote learning (Donnelly, Kirk & Benson 2012, 5). A mobile device, in turn, can be used as a learning tool in various learning contexts (Clough et al. 2008, 356). Therefore, mobile technologies have established a learning approach (i.e., mobile learning). There has been increasing interest in mobile learning across different sectors of education worldwide (Traxler 2007, 2). According to Futuresource Consulting (2014a), the tablet device was the fastest growing device category in education globally in 2014. Overall, it appears that recent educational spending has been driven by mobile devices (Futuresource Consulting 2014b).

Although the mobile device is one significant feature of mobile learning, this study emphasizes that mobile learning is not merely learning through use of mobile devices. It is also learning across different contexts and through social and content interactions that can be mediated via mobile devices. Learning can occur inside and outside the classroom and the learning situations can be either formal planned lessons or informal unplanned and spontaneous learning experiences (Crompton 2013a, 4). Furthermore, in this study, mobile learning is particularly viewed as a teaching method and practice. Teachers can employ a wide variety of teaching methods and practices as part of their pedagogical practices (Jarvis 2010, 148). Mobile learning is one option for extending and enriching both teaching and learning. It is also important to acknowledge that mobile technologies can be used in a variety of ways in an educational context. On the one hand, they can be used to enhance traditional curriculum-led and classroom-bound teaching and learning and, on the other hand, they can be used to promote more student-centered and innovative teaching and learning practices (Sharples 2013).

It is beyond the scope of this study to examine mobile learning in an informal educational context. Thus, the reader should bear in mind that the study will focus on mobile learning in a formal educational context. Formal education is a process in which knowledge is acquired through certain institutionalized organs of society (e.g., schools). Formal education involves a series of tasks and activities and usually has a long-term perspective. Thus, formal education is planned and deliberate (Johnnie 1993, 4), whereas informal learning is normally unforeseen and unplanned and can happen various contexts (Cross 2009, 135). Both teaching and learning are essential parts of education (Puri 2006, 1) even though, basically, there is no automatic link between teaching and learning (Illeris 2007, 2). Put simply, in formal learning, the goals and the process of learning are explicitly defined by a teacher or by an educational institution. In informal learning, the learner typically defines the learning goals and process. Sometimes informal learning is also unintentional, which means that the goals of learning are not specified in advance and there are no arranged learning processes. (Vavoula 2004, 5.) This kind of unintentional and unplanned learning is also called incidental learning (Kerka 200, 3; Scanlon et al. 2014, 239). Studying mobile learning in people's everyday life (i.e., informal and incidental mobile learning) would also be an interesting strand of mobile learning research and should be investigated in more detail in the future. However, because of the increasing presence of mobile technologies in the Finnish educational context, the study focuses on mobile learning in the formal educational context, mainly Finnish basic and secondary education settings.

TABLE 1 represents some of the devices that teachers utilize in the Finnish schools as well as the differences from those of previous years.

TABLE 1 The devices that teachers utilize as a part of their teaching practices in the Finnish schools and the differences from those of previous years (adapted from Opeka 2015)

	2015[1] (1653 respondents)	**2014 (4937 respondents)**	**2013 (5936 respondents)**	**2012 (2312 respondents)**
Laptop/desktop computer	98 %	97 %	96 %	89 %
Tablet device	49 %	51 %	17 %	10 %
Smartphone	42 %	38 %	20 %	7 %

The data in TABLE 1 is provided by Opeka, an online tool that is used to evaluate how Finnish teachers use information and communication technology (ICT) as well as the ICT environment and culture in the school. Opeka provides information at the teacher level, school level and national level. TABLE 1 specifically represents the question that relates to devices. In this question, the respondents select the devices that they use in their teaching from a pre-constructed list or by adding one's own choice. These data suggest that the mobile technologies have become more common in the Finnish educational context.

The formal education in Finland comprises levels from pre-primary to higher education (FIGURE 1). In Finland, all people have equal access to education and training. Compulsory basic education usually starts at the age of seven and lasts for nine years. Most students continue their studies after basic education in either general or vocational upper secondary education. There are basically no dead-ends and learners can always continue their studies on higher levels of education. Basic and upper secondary education is maintained by local authorities or jointly by municipalities. The Finnish National Board of Education implements the policy aims for early childhood, pre-primary, basic, upper secondary and adult education, but the education providers usually

1 The respondents at 13.8.2015 (total of 1653 respondents).

draw up their own local curricula based on the framework of the national core curriculum. Polytechnics and universities have the freedom to organize their own administration, decide on student admission, and design the contents of degree program. (CIMO, Ministry of Education and Culture & National Board of Education 2013; Finnish National Board of Education 2014b.)

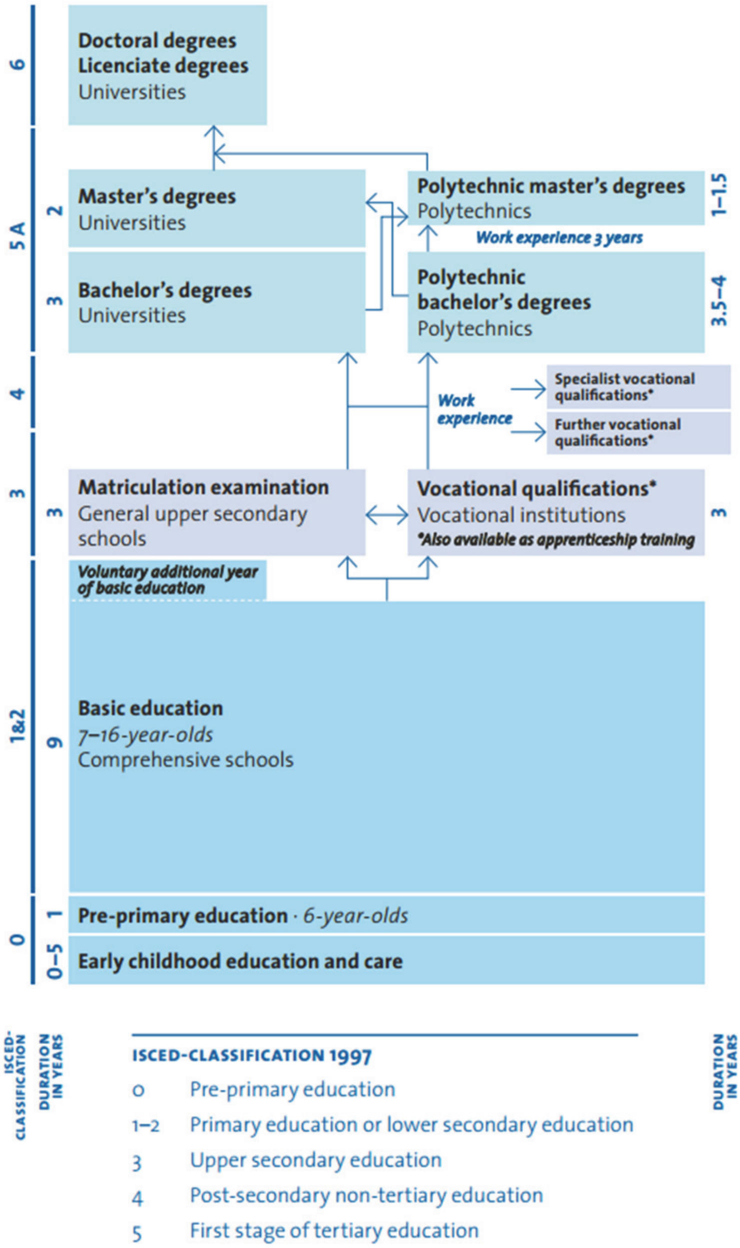

FIGURE 1 Formal education in Finland (CIMO, Ministry of Education and Culture, & National Board of Education 2013, 3)

The current approach to organizing basic and upper secondary teaching and learning in Finland is subject-based and academic in nature. Eighteen subjects are included in the national core curriculum (Vitikka, Krokfors & Hurmerinta 2012, 88). The government defines the time allocation for subjects in basic education; in other words, the government determines the distribution of teaching hours among various subjects. The computational lesson time is typically 45 minutes. (Opetus- ja kulttuuriministeriö 2012, 30.) The school year in Finland comprises 190 days between mid-August and the beginning of June. The minimum lessons per week vary from 19 to 30 and the school week comprises five days. Daily and weekly timetables are determined in the schools. (CIMO, Ministry of Education and Culture & National Board of Education 2013.) Hence, Finnish basic and upper secondary education is more or less scheduled on a semester, daily, and hourly basis.

In some subjects, such as mathematics and sciences, the teaching and learning style remains rather traditional, including direct teaching, solving basic problems, reading textbooks, and conducting practical work. (Krzywacki, Pehkonen & Laine 2012, 125; Lavonen & Juuti 2012, 138.) Finnish teachers in general appear to adopt new ideas and methods only if they find them meaningful and useful. Finnish teachers have a considerable amount of decision-making authority in schools and can determine their course contents and student assessment. They can also decide themselves which methods of teaching and textbooks/other materials they will use. (Krzywacki, Pehkonen & Laine 2012, 125.) Various teaching materials are available and the percentage of electronic material is increasing. Essentially, teachers can choose the textbook series and materials that appeal most to them. However, the economic situation of the school or teacher colleagues' opinions may restrict this freedom to some extent. (Tainio & Grünthal 2012, 157–158.)

The textbook still has a central role in the Finnish educational context and printed books are involved in daily routines to teach different subjects in the curriculum. Even though the opportunities to use information and communication technologies (ICTs) in Finnish schools to support teaching and learning have improved significantly, ICTs have not yet been widely integrated into everyday educational practices. (Vahtivuori-Hänninen & Kynäslahti 2012, 240.) For instance, large differences exist among regions, schools, and grades in terms of educational use of ICT (Kankaanranta et al. 2011, 71–72). TABLE 2 illustrates the number of devices per 10 students in Finnish basic and upper secondary education. The number still is rather small. Thus, equitable access to all students is not yet available. In upper secondary education, it is relatively common for students to use their own personal devices for studying. In basic education, in turn, the use of students' own devices is still unusual. (Jalava, Selkee & Torsell 2014, 11–20.) The Union of Upper Secondary School Students in Finland (2013, 16–21) has stated that 80% of the upper secondary school students has their own laptop, 77% has a smartphone, and 16% has a tablet device. Thus, most upper secondary students already have the opportunity to utilize their own equipment for studying. However, these students rarely use their own equipment during lessons.

TABLE 2 Number of devices per 10 students in Finnish basic and upper-secondary education (adapted from Jalava, Selkee & Torsell 2013, 11–20)

	Devices per 10 students	
	Basic education	Upper secondary education
Desktop computer	1,63	1,82
Laptop computer	0,84	1,88
Tablet device	0,37	1,07
Smartphone	0,12	0,15

Recently, there has been a lot of hype surrounding the use of tablet devices in the Finnish educational context (see Yle 2012; Dvergsdal 2013). For example, the City of Vantaa announced that it will purchase more than 16,000 tablet devices for educational purposes (Ylönen 2014). The Finnish National Board of Education has also funded projects that aim to bring updated information for how to integrate mobile technologies in an educational context (see Oppiminen 2014). Thus, this study is topical; it provides an understanding of mobile learning and factors influencing it in the Finnish formal educational context that have not been explored extensively.

1.1 Statement of the Problem

Even though researchers have shown increased interest in mobile learning and research in the field of mobile learning has been conducted all over the world (Traxler 2007, 2), one of the greatest challenges is that mobile learning solutions have not yet been widely integrated into everyday educational practices. Researchers have agreed that mobile technologies have great potential to improve teaching and learning. Some authors have highlighted that with mobile learning, learning can take place in different contexts inside and outside the classroom (Traxler 2007, 7; Shih et al. 2011, 390–391) and that mobile devices at their best can enable learning that is "just in time, just enough, and just for me" (Peters 2005, 3; Traxler 2007, 5). However, far too little attention has been paid to educational practices. On the whole, mobile learning developments have tended to focus more on technologies and tools than on learning (Kearney et al. 2012, 1). Also, in many cases, the trials have been short term and small scale (Rushby 2012, 355–356) or implemented by enthusiastic individuals (Lefoe et al. 2009, 16). In fact, enthusiastic teachers alone are unlikely to bring the breadth of mobile learning integration desired (Passey 2010, 80). Rushby (2012, 355–356) highlighted that research in the field of mobile learning should offer proof of educational outcomes and impacts.

Educational outcomes and impacts, however, cannot be fully assessed before the use of mobile technology in education is integrated into everyday educational practices or at least all affecting variables are well known. For instance, when mobile learning employs design and evaluation principles taken from traditional or electronic learning, it may fail to take into account the unique possibilities of learning through mobile technologies (Shuler 2009, 7). Chu (2014), for example, argued that using mobile devices to learn in an authentic learning environment is not always successful and therefore it is important to investigate different learning strategies as well as develop new strategies that consider the special features of mobile learning.

Furthermore, most mobile learning projects occur in isolation and are disconnected from teacher development programs and broader ICT initiatives and goals (UNESCO 2011, 15). Thus, many mobile learning projects may not have had a direct impact on educational practices. This has highlighted the need for a solid framework (e.g., Frohberg, Göth & Schwabe 2009; Park 2011; Traxler 2007). Thus far, little theoretical or conceptual work has aimed to explain the complex interrelationships of mobile learning (London Mobile Learning Group 2014). This study therefore aims to tackle this challenge by trying to explain various aspects of mobile learning and the interrelationships that exist among them.

To enable long-term implementations and promote the evaluation and assessment of educational outcomes and impacts, this study aims to develop a mobile learning framework. A mobile learning framework provides strategies for pedagogically sustainable integration of mobile technologies in an educational context. Hence, the results of the study will contribute to the planning, implementation, and evaluation processes of mobile learning. Both the theoretical foundation of the study and the exploratory observations provide an understanding of mobile learning in a formal educational context and highlight the factors that affect the integration of meaningful mobile learning.

1.2 Research Questions

Based on the main objective of the study, to design a mobile learning framework (subchapter 1.1) within a formal educational context, the research questions are as follows:

1. What are the core aspects and characteristics of mobile learning in a formal educational context?
2. How do the core aspects and factors interrelate?
3. What other important factors affect the pedagogically sensible and sustainable use of mobile technologies in formal educational contexts?

1.3 Structure of the Thesis

The study is organized into seven chapters. The first chapter describes the context, purpose, and structure of the study. Chapter 2 is concerned with the methodology (i.e., design-based research) used for this study. The fourth, fifth, and sixth chapters present the design process of the mobile learning framework. Finally, Chapter 7 discusses and summarizes the results of the study.

2 DESIGN-BASED RESEARCH

To situate this study within an appropriate research paradigm, a design-based research paradigm was chosen. Therefore, the purpose of this chapter is to explain the methodological background of the study; namely, a design-based research. However, the reader should bear in mind that there are some differences in this research compared with the traditions of design-based research. These differences are described in subchapter 2.3. As already emphasized, the objective of the study is to promote mobile learning theory and practice (see subchapters 1.1 and 1.2). The intent is particularly to bridge the gap between theory and practice by developing a mobile learning framework and guidelines for successful mobile learning integration by employing a design-based research approach, including multiple-method data collection.

A design-based research approach has been utilized increasingly in educational contexts and especially with educational technology innovations and interventions (Anderson & Shattuck 2012, 25). Put simply, a design-based research approach means that researchers and teachers work collaboratively to plan for, carry out, analyze, and release notable changes to teaching and learning (Stemberger & Cencic 2014, 65). Wang and Hannafin (2005, 6–7) defined a design-based research approach as follows:

> A systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among a researcher and practitioners in real-world settings and leading to contextually-sensitive design principles and theories.

Thus, the goal of design-based research is to design and develop interventions (e.g., programs, teaching and learning strategies, materials, systems) to solve complex problems. By its nature, design-based research is highly relevant to educational practice. A variety of functions are used to design interventions, including the preliminary research, prototyping, and assessment. Hence, the design-based research approach incorporates cycles of analysis, design, evaluation, and revision. (Plomp 2007, 11–15.) These research cycles are dynamic and integrate multiple exploratory, constructive, and empirical research methods and strategies as well as manifold design techniques (Bannan 2007, 56).

It was decided that the best method to adopt for this study was the design-based research approach. First, the study focuses on educational practice (i.e., mobile learning). Second, the concept of mobile learning is relatively novel and challenging and, third, the aim of the study is to design and develop a framework to support mobile device implementation in an educational context and to advance mobile learning theory. Park (2011, 83) emphasized that a theoretical framework can guide effective instructional design and evaluation of mobile learning implementations. Hence, a mobile learning framework and guidelines can bridge the gap between theory and practice and enable pedagogically sensible and sustainable integration of mobile technologies in educational contexts. At the same time, the framework and guidelines can also build a theoretical base for mobile learning which otherwise is somewhat fragmented at the moment (see Viberg & Grönlund 2012).

The following subchapters will clarify the design-based research approach further. First, the principles for how design-based research can be implemented are discussed (subchapter 2.1). The issues related to the trustworthiness of the design-based approach are examined in subchapter 2.2. Finally, subchapter 2.3 introduces how the design-based approach is applied in this study.

2.1 Implementing Design-Based Research Methodology

The design-based research approach offers the possibility to research novel phenomena in authentic classroom environments with ordinary teachers and students (Juuti & Lavonen 2006, 65). This means that the research is situated in an educational context (Anderson & Shattuck 2012, 16). The starting point is usually an educational problem for which only a few guidelines exist for how to structure and support the design and development (Plomp 2007, 13). Hence, design-based research particularly focuses on the design and testing of significant interventions. Design-based research also involves a collaborative partnership between a researcher and practitioners. (Anderson & Shattuck 2012, 16–17.) The role of the researcher and practitioners, naturally, varies depending on the research aims and objectives (Juuti & Lavonen 2006, 55). The design-based research approach can also include design work that takes place outside the classroom context and only among research teams. In other words, it concerns work that does not involve participants. (Leinonen et al. 2014, 6.)

Wang and Hannafin (2005, 7) argued that design-based research has five key characteristics. First, it is pragmatic. Design-based research focuses on practical problems; however, the theory development is also inextricably linked to the practical process (Wang & Hannafin 2005, 8). In other words, knowledge and action are combined (Juuti & Lavonen 2006, 57). Second, design-based research is grounded, which means that the research is rooted in relevant research, theory, and practice as well as real-world contexts. Third, design-based research is interactive, iterative, and flexible. It is largely a collaboration and interaction among a researcher and practitioners. (Wang & Hannafin 2005, 8–9.) Development and research take place through iterative cycles of analysis, design, implementation, and redesign (Design-Based Research Collective 2003). The design process also allows for flexibility, which means that the researcher can make deliberate changes when necessary. Fourth, design-based research is integrative, incorporating several research methods and approaches. A variety of research methods is used to maximize the credibility of the research, and these methods may evolve and change during the research phases. Finally, design-based research is also contextual, which means that the research results are linked with the design process in which the discoveries have been made and the context in which the research is conducted. (Wang & Hannafin 2005, 9–12.)

As mentioned earlier, in design-based research the interventions are developed in a cyclical process. This means that if a certain cycle of the intervention does not result in the desired outcomes, and therefore the intervention is not yet sufficiently effective, the cycle will be re-designed to enhance the intervention. (Plomp 2007, 18–19.) Reeves (2006) divided the design-based research process into four phases (FIGURE 2). Phase 1 includes analysis of the practical problems. Phase 2 focuses on designing and developing solutions to the problem. In phase 3, iterative cycles of implementation and evaluation are conducted. Finally, phase 4 includes reflection.

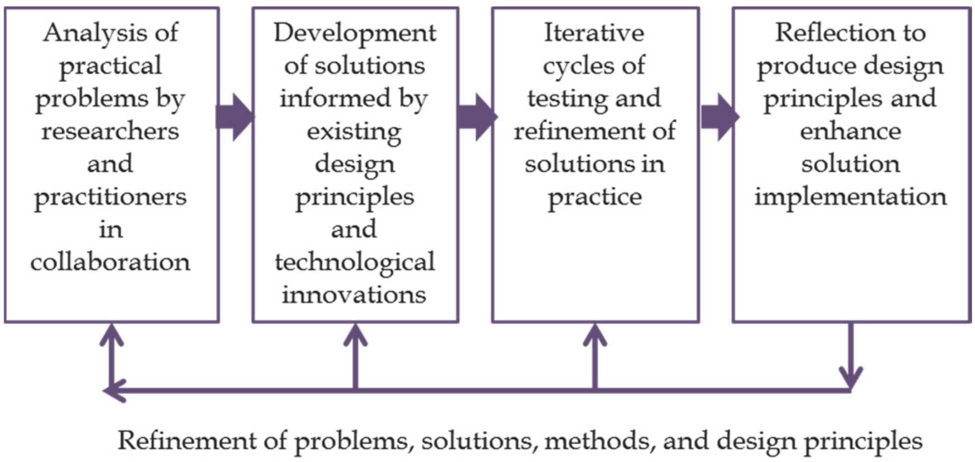

FIGURE 2 Design-based research (adapted from Reeves 2006, 59)

Usually, a design-based research project starts with the recognition that something is problematic. At first, the intent is to find answers in the available literature and other sources and to determine the best way to approach the problem; in other words, the intent is to analyze the observed problem. The aim is also to compose a tentative strategy by which to manage the problem (i.e., to develop an initial solution). After this, the target is to use the composed strategy to collect feedback and improve the strategy. Hence, three essential aspects of the design-based research process can be defined as follows: (1) to understand and specify the context, user requirements, and objectives so as to design an artifact, (2) to iteratively design and test the artifact, and (3) to acquire novel knowledge about teaching and learning. (Juuti & Lavonen 2006, 60.) Because interventions and innovations are rarely perfectly designed initially, there is always room for improvement and re-evaluation; in other words, iterations are necessary in the design-based research approach (Stemberger & Cencic 2014, 65). Therefore, design-based research normally involves multiple iterations (Anderson & Shattuck 2012, 17). Hence, three features determine and constitute design-based research: (1) The design process is essentially iterative, (2) the objective of the design-based research is to develop an artifact to help teaching and learning in a way that leads to learning, and (3) design-based research offers new educational knowledge about teaching and learning (Juuti & Lavonen 2006, 60). Design-based research, therefore, clearly has a practical impact on practice (Anderson & Shattuck 2012, 18).

There are a number of similarities between the design-based research and the action research paradigm. Both approaches favor interventions, are open, involve a reflective and often cyclic process, and aim to bridge theory and practice. However, in design-based research, design has a crucial role, whereas in action research, the focus is on action and change. Design-based research also usually targets instructional theories. (Bakker & van Eerde in press.) Reeves (2000, 7) argued that in the action research approach there generally is little or no effort to construct theory, models, or principles to guide future design initiatives. Thus, action research is basically composed of a balance of three elements: action, research, and participation. If any one of these elements is absent, then the process is not action research. Hence, action research is a participatory process in which everyone involved takes some responsibility. (Greenwood & Levin 2007, 7.) Thus, in action research, the research focus is usually chosen collaboratively among the participants and the researcher, and the relationships among the participants are organized as joint learning processes (Greenwood & Levin 2007, 2–3). Therefore, in action research, the participants usually initiate the research and the researcher comes to facilitate the research process (Peer Group 2006). Consequently, action research may have an impact on both school improvement and the professional development of teachers (Costello 2003, 26). The design-based research approach, in turn, is actually a series of approaches whose intent is to construct and produce new theories, artifacts, and practices that affect learning and teaching in naturalistic settings (Barab & Squire 2004, 2). Design-based research refines both theory and practice (Wang & Hannafin 2005, 13). The approach can be used to compose a coherent methodology to bridge theoretical research and educational practice (Design-Based Research Collective 2003). Furthermore, in design-based research, the researcher can play a role as designer and researcher. Hence, in design-based research, the researcher and participants cooperatively construct interventions and artifacts. (Wang & Hannafin 2005, 10.)

2.2 Ensuring Trustworthiness of the Research

Kirk and Miller (1986, 20) stated that the objectivity of a study involves the simultaneous realization of as much reliability and validity as possible. Reliability means the degree to which the finding is independent of accidental circumstances of the research, and validity is the degree to which the finding is interpreted correctly (Kirk & Miller 1986, 20). Robson (2002, 93) added a third concept: generalizability. According to Robson (2002, 93), generalizability combined with validity and reliability makes the study believable and trustworthy. Generalizability refers to the extent to which the findings of the research generally apply outside the specific research situation (Robson 2002, 93).

Significant debate surrounds the question of whether or not concepts such as validity and reliability should be applied to qualitative research. Guba and Lincoln (1981, 103–127) highlighted that one consequence of a qualitative approach is that hypotheses can never be directly confirmed. Another challenge is generalizations, which are not possible because phenomena are intimately tied to the times and the contexts in which they are found. Furthermore, in quantitative research, all instrumental shifts can be treated as errors, but in qualitative research the main instruments are humans and changes occur because of evolving insights and sensitivities. Therefore, reliability is challenging. In qualitative research, there basically are multiple realities and thus objectivity is also somewhat challenging. (Guba & Lincoln 1981, 103–127.) Various sets of alternative criteria have been suggested for qualitative research. Guba (1981, 80) proposed four criteria for evaluating the validity and trustworthiness of qualitative research: credibility, transferability, dependability, and confirmability (see TABLE 3).

TABLE 3 Four aspects of trustworthiness (Guba 1981, 80)

Criteria for Quantitative Research	Criteria for Qualitative Research
Internal validity	Credibility
External validity Generalizability	Transferability
Reliability	Dependability
Objectivity	Confirmability

Credibility means that the study findings are believable (i.e., confidence in the "truth" of the findings). Transferability refers to the degree to which the findings can be generalized or transferred to other contexts (i.e., applicability). Dependability refers to the study's stability and traceability, that is, the extent to which the findings are consistent and can be repeated. Confirmability is the degree of neutrality or the extent to which the findings are shaped by the respondents and not researcher bias or assumptions. A range of strategies can be adopted to respond to the above issues, including triangulation, sampling, and reflexivity. (Guba 1981, 83–88.) Some of these strategies are summarized in TABLE 4.

TABLE 4 Modes for addressing the questions of trustworthiness (adapted from Guba 1981, 83–88)

Criterion	Mode for Dealing with Criterion
Credibility	Triangulation via use of different methods, different types of respondents, different perspectives Peer debriefing; exposing thinking to peers
Transferability	Purposive sampling Collecting thick descriptive data; describing the research context and the presumptions that were central to the study
Dependability	Overlap different methods; triangulation In-depth documentation of how the data were collected and analyzed to allow study to be repeated
Confirmability	Triangulation to reduce effect of researcher bias; collecting data from a variety of perspectives, using a variety of methods, and drawing upon a variety of sources Practicing reflexivity; revealing underlying assumptions and shortcomings

The criteria introduced by Guba (1981, 83–88) can also be considered in design-based research to pursue trustworthiness. First, ensuring credibility is one aspect of establishing trustworthiness. Credibility refers to the plausibility of a report, that is, whether it is believable (Lincoln 2004, 1145–1146). Several strategies can help to enhance credibility during data collection, analysis, and reporting: triangulation, a prolonged engagement, and peer debriefing (Guba 1981, 84–85; Anney 2014, 276–277; McGinn 2010, 5–6). Triangulation via the use of different methods, different types of respondents, and different perspectives can help the researcher reduce bias and cross-examine the data (Anney 2014, 277). For instance, investigator triangulation (i.e., using several different investigators in the analysis process) can increase the trustworthiness of the findings (Guion, Diehl & McDonald 2013, 1–2).

Another strategy for ensuring credibility is peer debriefing. In peer debriefing, the researcher's thinking is exposed to peers, which may help to improve the quality of findings (Anney 2014, 276–277). For example, in design-based research, the developed intervention can be improved through expert appraisal, micro-evaluations, try-outs, and field tests (van den Akker 2007, 47). Also, a prolonged engagement in the fieldwork can ensure credibility because it helps to develop trust with study participants and furthers understanding of the core issues that might affect the quality of the data (Anney 2014, 276). In addition, the pre-interviews or pre-testing may help to determine whether the data collection tool is suitable for obtaining the rich data needed to answer the research questions. Interview tapes and transcribed texts can support the data analysis and ensure its trustworthiness. Also, detailed descriptions of the analysis process should be provided. Thus, data collection, analysis, and results reporting should go hand in hand. (Elo et al. 2014, 1–10.) At their best, thick descriptions can help the reader understand the study and determine its credibility (McGinn 2010, 5–6).

Transferability refers to the ability to use and transform the findings in another setting (Lincoln 2004, 1145–1146). A design-based researcher normally focuses on specific objects and interventions in specific contexts. This context-bound nature of design-based research also explains why it usually does not strive toward context-free generalizations. Typically, if an effort to generalize is made, it is an analytic generalization. (Plomp 2007, 16.) Essentially, thick descriptions of the study will help readers judge the transferability of the study. Thus, the researcher should provide a detailed description of the study and the participants because it facilitates the transferability of the study (Anney 2014, 278). This highlights the importance of ensuring high-quality results and reporting of the analysis process. Also, clear descriptions of the culture, context, and selection and characteristics of participants should be provided. (Elo et al. 2014, 1–10.)

Dependability refers to the stability, traceability, and logic of the research process employed. Confirmability certifies that the data reported can be pursued all the way back to the original data sources. (Lincoln 2004, 1145–1146.) Thus, the findings should reflect the participants' voices and the conditions of the study, not the researcher's biases, motivations, or perspectives. For example, quotations can confirm the connection between the results and data. (Elo et al. 2014, 1–10.) Dependability and confirmability can be improved, for instance, with triangulation, peer examination, iterative comparisons, and a reflective journal (Anney 2014, 279).

The use of multiple methods and data from different sources can increase the trustworthiness of the design-based research approach (Wang & Hannafin 2005, 17). Therefore, design-based research typically involves mixed methods using a variety of research tools and techniques (Anderson & Shattuck 2012, 17). The specific design task or specific reflected problem in action determines the data collection and analysis (Juuti & Lavonen 2006, 62). To increase the adaptability and generalizability (i.e., transferability) of the approach, guidance on how to apply the discovered findings in new settings is also required (Wang & Hannafin 2005, 12).

The design-based research approach, however, includes one fundamental challenge; how does a researcher ensure that the data collection method thoroughly covers the phenomenon being researched and how does one decide which data should be selected for detailed analysis? To manage this challenge, Juuti and Lavonen (2006, 64) suggested that explicit goals for a testing phase should be stated and that if these goals are not reached then something should be changed.

Hence, the trustworthiness of design-based research comes especially from making the reasoning behind any generalized claims explicit, public, and open to critical reflection and discussion. Results should be presented in such a way that readers are enabled to clearly understand the motivation and reasoning behind claims. Hence, sufficient information should be provided so that generalized claims can be verified. (Obrenović 2011, 59.) In other words, the researcher shows that through the process something new has been produced, provides details of how the developed artifact has been tested and revised, and describes why particular research methods have been employed to collect the data (Juuti & Lavonen 2006, 65).

Because this study involves design-based multidisciplinary qualitative research, it also adapts the four aspects of trustworthiness and the modes to address the criteria introduced by Guba (1981). The trustworthiness of the present study is discussed in the conclusion section (subchapter 7.3).

2.3 Applying the Design-Based Research Approach

The design-based research approach is appropriate for the present research problem, as the aim is to bridge the gap between theory and practice by designing and developing a mobile learning framework and related guidelines (subchapters 1.1 and 1.2). Furthermore, the role of the researcher is to perform research and design such a framework. In relation to traditions, the collaborative partnership in this study is organized differently. The role of the teachers is to design the mobile learning activities. The decision for the role of the researcher in the design process of the mobile learning activities to be minimized was made because the objective is to design a framework that would describe the impartial aspects that affect mobile learning in naturalistic settings. Thus, the mobile learning activities that the teachers themselves design would give valuable data for the design work of the framework which takes place outside the classroom context. Thus, the actual design work of the framework does not involve participants. However, without the teachers' and students' contribution the design work would be impossible. Therefore, teachers' and students' activities and feedback play significant roles in the design work.

TABLE 5 combines and summarizes characteristics of design-based research defined by Wang and Hannafin (2005), Juuti and Lavonen (2006), and Andersson and Shattuck (2012) and how those characteristics are concretized in this research. Thus, as mentioned earlier, the overall aim of this study is to design a mobile learning framework that can facilitate the pedagogically sensible and sustainable integration of mobile technologies in educational contexts (see subchapter 1.1). In other words, the study focuses on a practical problem: how to best promote mobile learning in a formal educational context. The theory development is also closely linked to the process. Hence, the aim is also to promote mobile learning theory. The theory also directs the design process because the designed framework reflects the existing mobile learning literature. The artifact that is designed and developed during the design process is a mobile learning framework and related guidelines. Therefore, another goal of the study is to provide essential information about the important aspects and factors that affect meaningful mobile device use in an educational context. The research is also situated in an educational context in authentic educational environments and thus highlights the actual ways teachers use mobile technologies as part of their teaching practices as well as the challenges they encounter when integrating mobile devices into teaching and learning.

TABLE 5 Characteristics of design-based research in this study

Characteristic (Andersson & Shattuck 2012; Juuti & Lavonen 2006; Wang & Hannafin 2005)	Concretized in this research
Focusing on the design and testing of a significant intervention/artifact/theory	The aim of the study is to design and evaluate a mobile learning framework for a formal educational context.
Offers new educational knowledge about teaching and learning	The study provides essential information about the important aspects and factors that affect meaningful mobile device usage in the educational context.
Being situated in a real educational context	The four case studies were conducted in authentic educational environments where the teachers used mobile technologies as a part of their teaching practices. In the online survey, the teachers' answers reflected their mobile learning practices in the educational context.
Using mixed methods/integrative	A literature review, case studies, and an online survey were employed as research strategies. Data in case studies were collected via interviews, surveys, and observations.
Involving multiple iterations	The research includes three design cycles.
Involving a collaborative partnership between researchers and practitioners/interactive	The teachers' and students' participation and feedback played a significant role in design and development of the mobile learning framework.
Evolution of design principles/pragmatic	A mobile learning framework and principles for advising mobile device integration in the educational context are designed and developed.
Grounded	The initial mobile learning framework was constructed based on earlier mobile learning frameworks and the mobile learning literature. The theory development was closely linked to the process.

2.3.1 Cyclic Design Process

As is typical for design-based research (see subchapter 2.3), the present study proceeds in cycles and the design process is iterative. The mobile learning framework is developed through cycles of analysis, design, evaluation, and revision. The aim of the analysis is to identify the aspects that should be taken into account in the design phase. In the design phase, the mobile learning framework is developed. This means that observations made in the analysis phase are encapsulated in the form of a framework. The developed mobile learning framework is also tested and evaluated. Multiple methods using a variety of research tools and techniques are employed to collect data in this phase. Each design cycle also includes a reflecting phase in which the observations made in the evaluation and analysis phases are summarized. The reflection phase includes dialogue with the findings; it summarizes the main observations and reviews how the aspects defined and described in the analysis phase have been realized and whether there is a need to further develop the framework.

The cyclic structure of the design and development process is illustrated in FIGURE 3.

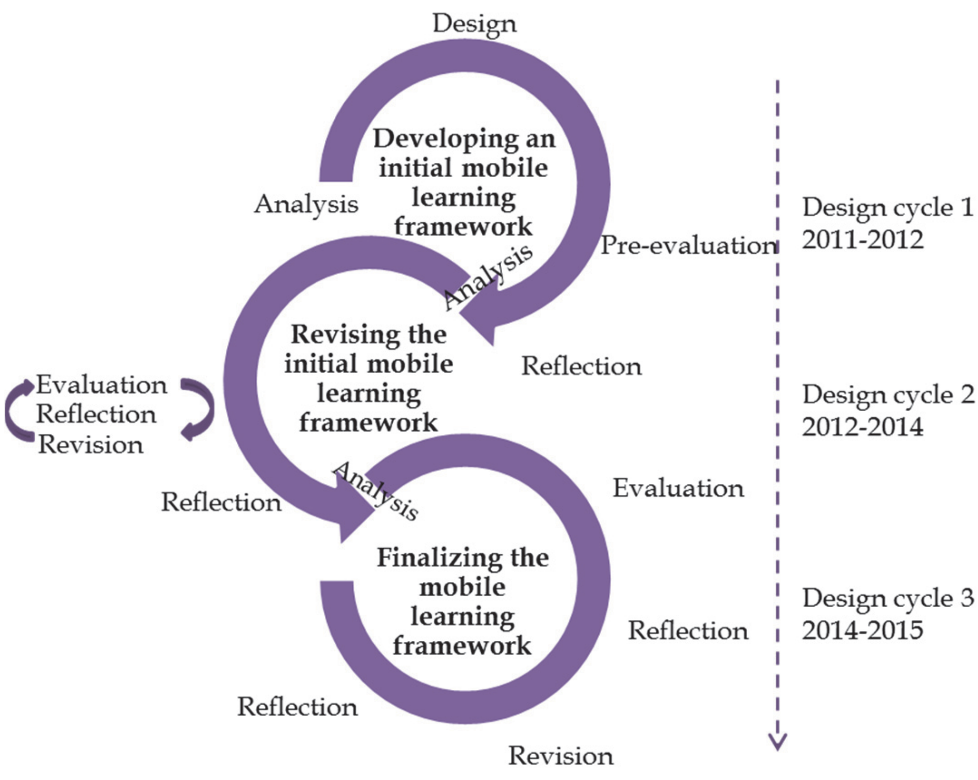

FIGURE 3 The cyclic structure of the research

The design process is divided into three design cycles. In the first design cycle, an initial mobile learning framework is developed and pre-evaluated based on the literature. In the second design cycle, the initial mobile learning framework is evaluated through fieldwork and revised based on the findings. Finally, in design cycle three, the mobile learning framework is once more evaluated and finalized. The findings and discoveries made in the second design cycle can also be presented as scientific articles (see Rikala & Kankaanranta 2014a; Rikala & Kankaanranta 2014b; Rikala 2014a; Rikala 2014b; Rikala 2014c; Rikala, Hiltunen & Vesisenaho 2014) and thereby the framework can be validated from the inter-researcher perspective. Both the observations and reflections made in design cycles as well as the experts' feedback highlight the necessary changes, which are made in the revision phase if needed.

2.3.2 Using Multiple Methods

Overall, a research project can have several functions: to describe, to compare, to evaluate, to explain or predict, and to design/develop. In many cases, several functions must be applied to address a research question. For example, if a researcher wants to design and develop a teaching strategy, then that researcher may first want to understand and describe any barriers to learning. In turn, when determining the efficacy of the developed teaching strategy, evaluation is necessary. Thus, other research functions can be applied to serve the primary research function. (Plomp 2007, 11–13.)

Furthermore, the research approach can use a qualitative, quantitative, or mixed method. Perhaps the simplest way to distinguish between qualitative and quantitative methods is to say that qualitative methods involve a researcher describing characteristics without comparing them in terms of measurements or amounts. In contrast, quantitative methods focus primarily on measurements and amounts of characteristics. (Thomas 2003, 1–15.) Thus, at the core of quantitative research are variables and measuring how they change (Martin & Bridgmon 2012, 3). The primary aim of qualitative research, in contrast, is to provide a detailed description of the phenomenon being researched. Qualitative researchers are interested in understanding how people interpret experiences, how they construct their words, and what meanings they attribute to their experiences (Merriam 2009, 8–9). Therefore, qualitative research focuses on in-depth understanding. Researchers explore new ideas and discover patterns. (Hoy 2010, 1–23.) The focus is on process, understanding, and meaning. In qualitative research, the researcher is typically the primary instrument of data collection and analysis. The process is inductive and the product is richly descriptive. Researchers gather data and build concepts, hypotheses, or theories rather than deductively testing hypotheses. Therefore, qualitative research is flexible and responsive to changing conditions. The sample selection is usually non-random, purposeful, and small. (Merriam 2009, 14–16.)

Qualitative research, however, is not appropriate for every research problem. When the interest is making systematic comparisons, then quantitative research is required. Quantitative methods can be used on larger samples, allowing inferences to be made to wider populations. (Silverman & Marvasti 2008, 11–12.) Quantitative research focuses on counting and classifying features as well as constructing statistical models and figures to explain the researched phenomenon. Thus, measurement and statistics are central to quantitative research and quantitative researchers are concerned with the development and testing of hypotheses and the generation of models and theories. (Hoy 2010, 1–23).

A mixed methods approach, in turn, is a procedure for collecting, analyzing, and mixing both quantitative and qualitative data in one study (Creswell 2012, 22). Thus, in a mixed research approach, the researcher uses a combination of quantitative and qualitative methods, approaches, and concepts in a single research study (Johnson & Christensen 2008, 51).

Also, many research strategies are available for conducting research and collecting data, including surveys, case studies, experiments, action research, ethnography, correlational research, evaluation research, and design research (Plomp 2007, 11–13), and combining methodologies may be appropriate for the research at hand (Cohen, Manion & Morrison 2013, 312).

This study is design-based multidisciplinary qualitative research that combines education, pedagogy, information technology, and to some extent psychology. It uses multiple methods to collect data. The goal is to understand and interpret the phenomenon of mobile learning and to design and generate a theoretical framework from the data collected from a small group of Finnish teachers and students. The designed framework is also evaluated. Thus, the research combines several functions; it describes, designs/develops, and evaluates. The design of the framework is completed in cycles. However, the study also integrates multiple methods and techniques to achieve the desired result. Therefore, the study also utilizes a literature review, case studies, and survey strategies for collecting the desired data. The research data are mainly qualitative data collected through observations, interviews, and questionnaires. This actually is a natural outcome of the research problem because the study focuses on examining the breadth and depth of mobile learning. TABLE 6 summarizes the data collection tools and methods employed in each design cycle and the following paragraphs describe these research strategies in more detail.

TABLE 6 Data collection methods and tools employed in each cycle

Data Collection Methods	
Cycle 1	**Literature review** (a non-systematic literature review of mobile learning research)
Cycle 2	**Case study 1** - teacher interview, student survey **Case study 2** - teacher interview, student survey, observations **Case study 3** - teacher interview **Case study 4** - teacher survey, student survey
Cycle 3	**Online survey**

Literature Review

According to Aveyard (2010, 5–6), a literature review is a comprehensive study and interpretation of the literature that addresses a specific topic. It can be regarded as a secondary analysis of knowledge (Aveyard 2010, 6; Jesson, Lacey & Matheson 2011, 11).

Literature reviews come in different shapes and formats. However, most can be categorized into two main styles: traditional and systematic. The review can be based on empirical primary research, research methods, theories, or practical interventions or it can be a conceptual review. The literature review can help to identify gaps in knowledge and clarify where no further research is needed. (Jesson, Lacey & Matheson, 2011, 15–17.) Therefore, analysis of earlier results may lead to new discoveries and insights (Aveyard 2010, 8).

The detailed type of literature review is referred to as a systematic review. The systematic review follows a strict protocol and uses explicit and rigorous methods to identify, critically appraise, and synthesize relevant studies to answer a predefined question. (Aveyard 2010, 13–14.) A systematic review has a clearly stated purpose, a question, a defined search approach, stated inclusion and exclusion criteria, and qualitative appraisal of articles (Jesson, Lacey & Matheson 2011, 12). A systematic literature review is also considered a research methodology (Aveyard 2010, 19).

Some literature reviews are undertaken with no defined method or systematic approach. These are referred to as narrative reviews or traditional reviews (Aveyard 2010, 16). Traditional reviews are often based on a personal selection of materials. The researcher chooses materials that he or she believes have some input to current knowledge. Therefore, traditional reviews may provide insights that are neglected or passed over in the exclusion and quality control required in the systematic review process. Hence, traditional reviews sit more easily in a more open qualitative and interpretative paradigm. (Jesson, Lacey & Matheson 2011, 15.) The challenge in the traditional style is based on a critique of the process; the design and method are open and flexible. In a traditional review, there is no need to provide a method report. Only the purpose of the review is described and there is no need to say how the sources were identified or what and why some were included and others excluded. (Jesson, Lacey & Matheson 2011, 24.)

In this study, a traditional literature review was used in design cycle one (see Chapter 4) to collect and interpret relevant information about mobile learning. A traditional literature review fits well with the design-based multidisciplinary qualitative research approach. Basically, the literature review both initiated the design-based research process and was the basis of the design of the initial mobile learning framework.

Case Study

A case study is a way to investigate an empirical topic (Yin 1989, 25). The case study attempts to explain and understand individual cases in their unique environments (Aaltio & Heilmann 2010, 69). Simons (2009, 21) defined a case study as follows:

> Case study is an in-depth exploration from multiple perspectives of the complexity and uniqueness of a particular project, policy, institution, programme or system in a 'real life' context. It is research-based, inclusive of different methods and is evidence-led. The primary purpose is to generate in-depth understanding of a specific topic (as

> in a thesis), programme, policy, institution or system to generate knowledge and/or inform policy development, professional practice and civil or community action.

Hence, case studies are the preferred strategy, especially when how or why questions are being posed, when the investigator has little control over events, or when the focus is on a contemporary phenomenon within some real-life context (Yin 1989, 13).

Challenges may arise when trying to generalize the results from case study research because what is observed is often contextually relevant to a particular phenomenon (Timmons & Cairns 2010, 100–103). Consequently, case study analysis does not strive for generalization; the objective is more to reach conceptions and understanding by moving from the specific toward the general. (Aaltio & Heilmann 2010, 67–78.) Hence, case studies are generalizable to theoretical propositions and not to populations or universes (Yin 1989, 21). Therefore, the researcher's conclusions and explanations of the case study may be the most generalizable aspect of case study research. The collected data may be specific to a particular school, or student, or teacher, but the explanations and conclusions may be useful in understanding how other schools, or students, or teachers work. (Gillham 2010, 12.) In other words, the researcher's goal is to expand and generalize theories, not to make statistical generalizations (Yin 1989, 21).

Thus, the primary aim of case studies is to look for patterns and ideas and to discover and build theory, rather than testing or confirming hypotheses (Davies 2006, 25; Vogt 2005, 114–115). Case study data and their analyses are used to develop theories regarding prior phenomena by pointing out paradoxes, bringing forward new observations gained from the thorough analysis, and pointing out the varied relationships between the individual cases and their environments. At their best, case studies can provide fruitful and nuanced results, and through such research it is possible to gain an overall and holistic picture of the research object. (Aaltio & Heilmann 2010, 67–78.) Case studies can document multiple perspectives and explore contested viewpoints. They also have the potential to engage participants in the research process. (Simons 2009, 23.)

In summary, the use of case studies creates knowledge and understanding. Case study methodology is flexible and allows the researcher to study a variety of phenomena ranging from unusual situations to complex interactions. (Timmons & Cairns 2010, 100–103.) Case studies can also employ various methods (Hamel, Dufour & Fortin 1993, 1). For example, case study strategy can use either qualitative or quantitative data or a combination of both. The researcher can gather data from the research object by using different types of observation and data gathering methods such as interviews, participatory observation, and survey. (Aaltio & Heilmann 2010, 67–78.) A kind of openness may also elicit what the actual theory of the case may be in practice (Simons 2009, 22). Therefore, the researcher should leave room for flexibility and surprise. Also, intuition has an important place in case study research. (Aaltio & Heilman 2010, 71.) According to Aaltio and Heilmann (2010, 69), the cornerstones of case study methods are the researcher's role in the research process, the context in which the research is carried out, connection of the research to existing theory, the use of various methods that aim to increase reliability throughout the process, and the researcher's committed and skillful analysis. Thus researcher subjectivity is an inevitable part of the case study; related concerns mainly focus on the personal involvement and/or subjectivity of the researcher (Simons 2009, 24).

In this study, the case study strategy was employed in design cycle two (see Chapter 5) when evaluating and revising the initial mobile learning framework. The use of a case study method was considered appropriate because the aim was to understand and examine in-depth the phenomenon of mobile learning. Thus, the case study would provide an understanding of and perspectives on mobile learning as well as outline various mobile learning aspects and factors.

Online Survey

Fink (2003, 2) argued that a survey is a system for collecting information from or about people to describe, compare, or explain their knowledge, attitudes, and/or behavior. Thus, a survey is a research style that includes systematic observations or interviewing (Sapsford 2006, 12). Surveys are undertaken for a wide variety of reasons. However, the central objectives can usually be identified as being focused on one or two of four goals: testing hypotheses, evaluating programs, describing populations, or building models of human behavior (Sonquist & Dunkelberg 1977, 1).

Traditional ways to administer surveys include, among other techniques, telephone interviews, mail questionnaires, and face-to-face interviews. In addition to these traditional techniques, online surveys such as e-mail and web-based surveys have also become common. (Sue & Ritter 2007, 1–3.) Online surveys in particular offer an effective way to gather information quickly and relatively inexpensively from a large geographic region (Sue & Ritter 2007, 9). Such surveys are based on a need to collect information from a sample of respondents from a well-defined population. The survey instrument typically contains a series of related questions for respondents to answer. (Czaja & Blair 2005, 3.) Surveys can be either quantitative or qualitative. Qualitative surveys usually ask open-ended questions where people respond in words. (Keith 2003, 1–2.) However, most often, the questions are in a closed format in which a set of response alternatives is specified (Czaja & Blair 2005, 3).

Like all measures, neither survey measurement is error free. The procedures used to conduct a survey influence the likelihood that the data will describe what they are intended to describe. Sampling, designing questions, and collecting data, for instance, influence the survey and its results. (Floyd 2009, 2–4.) Errors made in the data-collection process are basically irreparable and therefore it is necessary to carefully evaluate the design of the study. The questions and instruments should also be carefully and effectively pretested. (Sonquist & Dunkelberg 1977, 6.)

In surveys, the decisions surrounding sample selection are critically important and should be considered in light of the survey objectives (Sue & Ritter 2007, 25). The target population must be clearly defined. Usually this population is defined in terms of a simple combination of demographic characteristics and geographic boundaries. (Czaja & Blair 2005, 3.) For exploratory studies, convenience sampling may be sufficient, but if the aim is to make statistical inferences, then it is necessary to employ a probability sampling technique (Sue & Ritter 2007, 25). There are two types of samples: probability and nonprobability. Probability samples, or random samples, are such that every element has a known, nonzero chance of selection and the elements are selected through a random procedure. The nonprobability design includes convenience, purposive, quota, and snowball samplings. (Czaja & Blair 2005, 127.)

Convenience sampling is a nonsystematic approach that allows potential participants to self-select into the sample. For example, a questionnaire is posted on the web site for anyone to fill out. One challenge with respondents who self-select into a web questionnaire is that they tend to be individuals who have a particular interest in the survey topic. Thus, statistical inference is problematic. (Sue & Ritter 2007, 32.) Furthermore, in convenience samples, response rates are not meaningful. They can be reported if they can be computed; however, they cannot be interpreted in the same way as in probability samples (Schonlau, Fricker & Elliot 2002, 10). In summary, the sample should be a probability sample if the aim is to form a statistical basis and make inferences (Czaja & Blair 2005, 127). Non-accurate sampling can increase bias. This bias, in turn, can produce erroneous results that lead to false interpretations about the underlying population. (Murphy, Dean & Hill 2014, 301.) The goal of the survey and survey analysis, after all, is to answer the research questions; thus, the research should test hypotheses, estimate characteristics, model a set of variables, or address other well-defined goals (Czaja & Blair 2005, 3).

Also, properly constructed questions are essential because a survey question is a measurement tool (Sue & Ritter 2007, 38). Czaja and Blair (2005, 70) highlighted that one way to obtain a poor response rate is to ask questions that are difficult for respondents to answer. The best questionnaire items are short, unambiguous, and meaningful to respondents. Hence, poorly written and lengthy or double-barreled questions may confuse and frustrate participants and thereby result in increased non-response. (Sue & Ritter 2007, 38.) Sources for response errors include the respondents misunderstanding questions, not being able to recall information, and otherwise having difficulty answering, perhaps even purposely answering falsely (Czaja & Blair 2005, 222). The challenge of non-response can be reduced, for instance, if surveys are limited to special populations (Czaja & Blair 2005, 229). Online surveys are also well suited to situations in which interviewer bias or a tendency toward providing a socially desirable answer may threaten the validity of the data. Evidence also suggests that respondents provide longer and more valid answers in online surveys to open-ended questions. (Sue & Ritter 2007, 151.)

In this study, an online survey was employed during design cycle three (see Chapter 6) when evaluating and finalizing the revised version of the mobile learning framework. The rationale for the unusual research order is that the case studies in design cycle two were developed for a different project. Ordinarily, the online survey would reveal the issues and questions to take forward in empirical case studies. As already highlighted (subchapters 2.1 and 2.2), the design-based research approach also allows for flexibility, which means that the researcher can make deliberate changes when necessary and usually the specific design task or specific reflected problem in action determines the data collection and analysis. Therefore, an online survey was considered appropriate as it could reach a varying sample of Finnish teachers who already had utilized mobile devices as a part of their teaching practices. Thus, the online survey could deepen the understanding of mobile learning as well as the aspects and factors that influence the mobile learning integration process. Thus, the online survey could confirm the existing factors and aspects and highlight the missing ones.

3 MOBILE LEARNING

On a broad level, mobile technology can be comprehended as a part of ICT and educational technology. Educational technology integrates new and conventional technologies of instruction to achieve stated educational objectives (Hefzallah 2004, 53). The availability of diverse educational technology increased substantially during the 1990s (Choudhary 2008, 118). Before that time, many schools had computers, perhaps one or two per classroom, but the flood of technology acquisition in the 1990s created a completely different context and opportunities for learning as computers, the Internet, and software became increasingly available (Staples, Pugach & Himes 2011, 10). Today, several technologies offer a great deal of flexibility regarding when, where, and how education is distributed. FIGURE 4 represents the developmental stages of educational technologies through the ages. These stages span computer-assisted instruction, Internet-connected electronic learning, and wireless mobile learning. Mobile learning is now perceived as the next milestone of educational technology (Peng et al. 2009, 172). Also, the New Media Consortium Horizon Report Europe 2014 emphasized that mobility is a key feature of the digital age and a feature that is likely to shape the future of education (Johnson et al. 2014, 44–45).

Mobile learning has aroused increased interest all over the world (Traxler 2007, 2). However, despite the growing interest and hype around mobile devices and mobile learning, mobile learning is no longer considered a novelty. Even though the term mobile learning became recognized as a formal term only in 2005 (Crompton 2013a, 11), mobile learning itself has a surprisingly long history. Alan Kay envisioned a personal and portable learning device system, namely Dynabook, in the early 1970s (Kay 1972; Naismith & Corlett 2006, 3). Low and O'Connell (2006) argued that a book can be considered a mobile learning resource and in that sense learning has always been to some extent mobile.

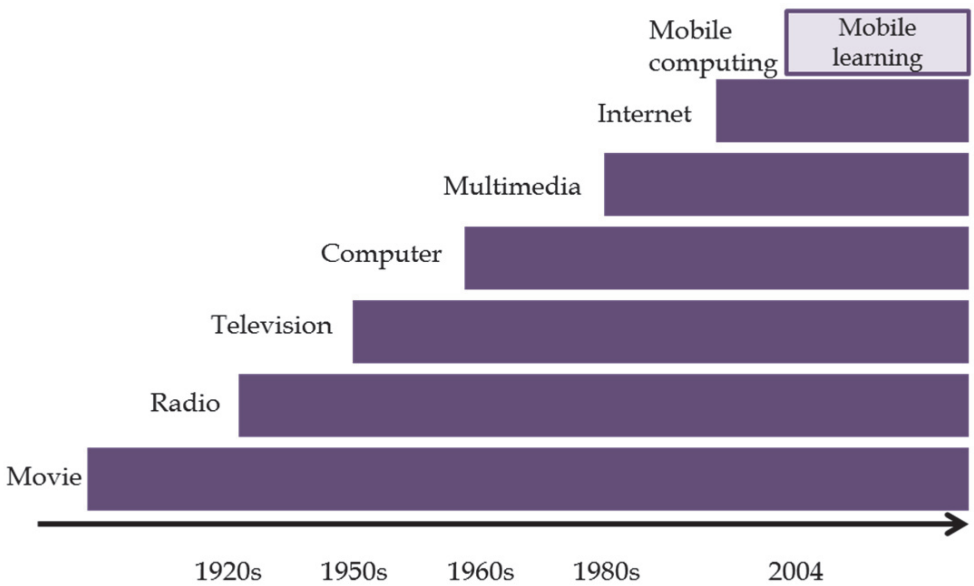

FIGURE 4 Educational technologies (adapted from Peng et al. 2009, 173)

New wireless and powerful mobile devices have new and exciting capabilities and possibilities, including multimedia, social networking, and geo-location (Kearney et al. 2012, 1). However, less robust mobile devices with slower communication capabilities have been used for teaching and learning for several years. Three applications (classroom response systems, participatory simulations, and collaborative data gathering) have been re-implemented and studied by many research teams (Roschelle 2003, 262).

The very earliest mobile technologies, however, lacked functionalities like screen size, processor speed, and battery life (Crompton 2013a, 11–12) and therefore only the latest mobile technologies have truly enabled learning on the move (Naismith & Corlett 2006, 3). Thus, even though mobile learning's roots are in the 1970s, its popularity did not peak until the twenty-first century (Lam, Yau & Cheung 2010, 307). In other words, mobile learning is still rather underdeveloped in comparison with other educational technologies and their pedagogies (Traxler 2007). Even the theoretical basis of mobile learning is currently under development (Kearney et al. 2012, 1). Hence, mobile learning has not yet reached a stable form and the whole concept of mobile learning continues to develop rapidly (Lam, Yau & Cheung 2010, 309). Thus, the concept of mobile learning is challenging as a commonly acknowledged definition and cohesive theory are missing (Frohberg, Göth & Schwabe 2009; Park 2011; Traxler 2007; Viberg & Grönlund 2012).

The following subchapters will discuss this still challenging concept. First, in subchapter 3.1, mobile learning is defined, after which related approaches are discussed in subchapter 3.2. Subchapter 3.3 describes the diverse theoretical perspectives and approaches of mobile learning. These theoretical underpinnings are concretized in subchapter 3.4, which summarizes some of the mobile learning examples linked to learning theories. Subchapter 3.5 discusses mobile learning activity design and subchapter 3.6 highlights other aspects that affect mobile learning adoption and integration. Finally, in subchapter 3.7, the theoretical underpinnings are summarized.

3.1 Defining Mobile Learning

Mobile learning can be defined in various ways because it means different things to different people (Laouris & Eteokleous 2005). Early perspectives of mobile learning mainly focused on technology, but currently several different mobile learning perspectives have focused on diverse features and aspects (see Keskín & Metcalf 2011). Traxler (2007, 8) argued that evaluating mobile learning highlights the problematic issue of defining and conceptualizing mobile learning, whereas Crompton (2013a, 3) stressed that if terms such as distance education are any indication, a lasting definition of mobile learning will not emerge for a long time to come. Furthermore, terms such as wireless, ubiquitous, seamless, nomadic, and pervasive learning are used to refer to mobile learning (Frohberg, Göth & Scwabe 2009, 308). TABLE 7 summarizes some of the mobile learning perspectives and definitions that have been used over time.

TABLE 7 Mobile learning definitions through the ages

Author (Year)	Definition
Quinn (2000)	Mobile learning is electronic learning through mobile computational devices: Palms, Windows CE machines, even a digital cell phone.
Vavoula and Sharples (2002)	Learning can be considered mobile: Learning is mobile in terms of space (i.e., it happens at the workplace, at home, and at places of leisure); it is mobile between different areas of life (i.e., it may relate to work demands, self-improvement, or leisure); and it is mobile with respect to time (i.e., it happens at different times during the day, on working days, or on weekends).
Trifonova (2003)	Mobile learning is any form of learning (studying) and teaching that occur through a mobile device or in a mobile environment.
Geddes (2004)	Mobile learning is the acquisition of any knowledge or skill through the use of handheld technology, anywhere and anytime.

(continues)

TABLE 7 (continues)

Author(s)(Year)	Definition
Georgiev, Georgieva, and Smikarov (2004)	The definition of mobile learning must include the ability to learn everywhere at every time without permanent physical connection to cable networks. This can be achieved through the use of mobile and portable devices such as personal digital assistants (PDAs), cell phones, portable computers, and tablet devices. The devices must have the ability to connect to other computer devices, to present educational information, and to realize bilateral information exchange between the students and teacher.
Laouris and Eteokleuous (2005)	The definition of the mobile learning (MLearn) function is: MLearn = f {t, s, LE, c, IT, MM, m} (where t=time, s=space, LE=environment, c=content, IT=technology, MM=mental abilities, and m=method)
Keegan (2005)	Mobile learning is the provision of education and training on PDAs/ palmtops/handhelds, smartphones and, mobile phones.
O´Malley et al. (2005)	Mobile learning is any sort of learning that happens when the learner is not at a fixed, predetermined location or learning that happens when the learner takes advantage of the learning opportunities offered by mobile technologies.
Traxler (2005b)	Mobile learning can be defined as "any educational provision where the sole or dominant technologies are handheld or palmtop devices."
Walker (2006)	Mobile learning is not about just learning using portable devices, but also learning across contexts.
De Marcos et al. (2006)	After presenting all these definitions, we can abstract three aspects recurrent in all of them: (1) To be mobile, learning should be able to be accomplished from any place, (2) should be able to be realized at any hour, and (3) it needs a device (small and easy to carry) that allows the student to complete the process.
Sharples, Taylor, and Vavoula (2007)	Mobile learning is the processes of coming to know through conversations across multiple contexts among people using personal interactive technologies.
Tétard, Patokorpi, and Carlsson (2008)	Mobile learning is situated, collaborative, and guided teaching, studying, and learning, supported by mobile devices that employ symmetric mobile communication channels that the learners and the facilitator can use; it can also involve specially designed learning objects for work, hobbies, or citizenship-related purposes or aids to traditional education.
Koole (2009)	Mobile learning is a process resulting from the convergence of mobile technologies, human learning capacities, and social interaction.
Peters (2009)	The key features of mobile learning are its ability to provide learning that is "just in time, just enough, and just for me", learning that is situated (typically in the field or at the workplace), and learning that is contextualized through mediation with peers and teachers.

(continues)

TABLE 7 (continues)

Author(s)(Year)	Definition
Peng et al. (2009)	To benefit from convenience, expediency, and immediacy, mobile learners use ubiquitous computing technologies to learn the right thing at the right time at the right place.
Cochrane (2010)	Mobile learning involves the use of wireless-enabled mobile digital devices (wireless mobile devices [WMDs]) within and between pedagogically designed learning environments or contexts.
Osman, El-Hussein, and Cronje (2010)	Mobile learning is any type of learning that takes place in learning environments and spaces that take account of the mobility of technology, mobility of learners, and mobility of learning.
El-Hussein and Cronje (2010)	The authors define mobile learning as a learning environment based on the mobility of technology, mobility of learners, and mobility of learning that augments the higher educational landscape.
ADL (2011)	Mobile learning involves leveraging ubiquitous mobile technology for the adoption or augmentation of knowledge, behaviors, or skills through education, training, or performance support while the mobility of the learner is independent of time, location, and space.
Crompton, Muilenburg, and Berge (2013)	Mobile learning is learning across multiple contexts through social and content interaction using personal electronic devices.

Most of these attempts to define mobile learning highlight the **mobility**[2] (TABLE 7). Mobility, in turn, is commonly understood as portable or movable (Naismith et al. 2005, 7), but it can be further identified at three distinct levels: spatial (space), temporal (time), and contextual (Serrano-Santoyo & Organista-Sandoval 2010, 86). Some uncertainty has existed about whether the focus should be on technology being mobile or the extent to which the learner is mobile. Traxler (2005b) argued that when mobile learning is contemplated from the learners' perspective, its definition may become explicit. El-Hussein and Cronje (2010, 17) stressed that the concept of mobility in an educational context can comprise three areas: mobility of technology, mobility of a learner, and mobility of learning. All of these characteristics of mobility indicate that mobile learning means learning that can occur **anywhere** and **anytime** (Traxler 2007, 2; Shih et al. 2011, 374). Mobile learning can occur in different contexts inside and outside the classroom (Crompton 2013a, 4). Hence, mobile learning is also learning **across diverse contexts** (Walker 2006, 3). What is noteworthy is that the mobile learning context is dynamic – from primary and secondary education to higher education and corporate learning settings and from formal and informal learning to classroom learning, distance learning, and field study (Park 2011, 79). This study particularly focuses on mobile learning in formal educational settings.

Mobile can also denote **personal**. First, mobile devices normally support a single user and are therefore perceived as being private and personal devices

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2 The mobility of learners, of devices and connectivity, of contents, of learning environments, or of learning.

(Naismith et al. 2005, 8). Second, mobile learners can choose the place, pace, and time when they study (Kearney et al. 2012, 9). Thus, mobile learning can be student-centered. Mobile learning, in particular, enables learning that is "just in time, just enough, and just for me" (Peters 2005, 3). At its best, mobile learning can meet learners' needs (Attewell, Savill-Smith & Douch 2009, 3). Therefore, mobile learning can be highly motivating for learners. Motivation, in turn, is a significant aspect of learning as it guides individuals' behavior toward reaching a specific goal (Wiseman & Hunt 2008, 43–87).

Moreover, mobile learning is also **interactive.** The learning process is happening through numerous social and content interactions, which are mediated through mobile devices (Crompton 2013a, 4). Learners can move within different locations and participate and interact with other people, information, and systems (Koole 2009, 26). In other words, learners do not study in a vacuum. They learn together with their peers and their teachers, they learn while collaborating, by doing as well as by correcting their misconceptions. (Laouris & Eteokleous 2005.)

In summary, mobile is not simply a synonym for a mobile phone or device (Laouris & Eteokleous 2005). A mobile device enables learning on the move (Naismith & Corlett 2006, 3). However, mobile learning is not merely learning with the use of mobile devices. In mobile learning, learners can learn across time and space (Sha et al. 2012, 375). Learning can occur outside the classroom and learning materials are not limited to textbooks (Shih et al. 2011, 390). Mobile devices, for example, enable flexible access to multimedia and information and enable communication, data capturing, and content creation in situ (Cheung & Hew 2009, 156–157). Thus, mobile technologies have great potential to extend and enhance teaching and learning (Kukulska-Hulme 2009).

In this study, mobile learning is defined as a teaching and learning approach that employs mobile devices to extend traditional teaching and learning and to sustain high levels of student engagement with rich connections to other people and resources across different contexts.

3.2 Related Approaches

Mobile learning has often been associated with electronic learning or distance learning (Traxler 2009a; Lam, Yau & Cheung 2010). Electronic learning and distance learning are types of learning in which instructors and students interact at different times and different spaces with technology that bridges the time-space gap, allowing learners to access materials at their own pace and with methods that are convenient for them (Karadeniz 2009; Rosen 2009). Particularly in electronic learning, various technologies and networks are involved (Tsai & Machado 2002). Some of the earliest definitions of mobile learning defined mobile learning as electronic learning with the use of mobile technologies (e.g., Quinn 2000), a natural evolution of electronic learning, or a new form/stage of electronic learning (e.g., Mostakhdemin-Hosseini & Tuimala

2005; Georgiev, Georgieve & Smrikarov 2004; Lehner & Nösekabel 2002; Motiwalla 2007;). Evans (2008, 492), for instance, highlighted that mobile learning inherits the advantages [3] of electronic learning; however, mobile devices can extend their reach by allowing learners to vary their study location and to study on the move.

In many cases, mobile learning is also seen as a method for blending formal and informal learning (Ahonen et al. 2002). Blended learning in general means structured opportunities to learn that use more than one learning or training method, inside or outside the classroom. Thus, blended learning allows the integration of a rich selection of learning opportunities prompted by many needs and situations. (Pankin, Roberts & Savio 2012.) Blended learning, for instance, can combine both synchronous and asynchronous methodologies, such as face-to-face learning and technology-based methodologies (Glazer 2011, 2).

Mobile learning has also been described with terms such as ubiquitous and flexible. On a broad level, ubiquitous learning encompasses the multiple forms of electronic learning and mobile learning where technology is used in various tasks. Therefore, ubiquitous learning is not constrained by physical space, plans, or timetables. It is pervasive and can occur anywhere and anytime. (Nicholas 2011, 33–34.) Yahya, Ahmad and Jalil (2010, 125) argued that learning styles have progressed from e-learning to mobile learning and from mobile learning to ubiquitous learning.

In flexible learning, learners have flexible access to learning experiences in terms of time, place, learning style, content, and assessment. Flexible learning requires the active engagement of students and students are also considered more responsible for their own learning. Thus, learning is usually student-centered. Flexible learning also includes, among other things, collaboration in the field and context-sensitive learning experiences that take into account the learner's current task and situation. (Chen 2003.) Brown (2003, 4) argued that mobile learning is a subset of electronic learning, which is a subset of distance learning. Distance learning, in turn, is seen as a subset of flexible learning. Also, Peters (2005; 2007) and Low and O'Connell (2006) argued that mobile learning is linked to a model of flexible learning. Mobile devices afford opportunities to access learning materials, activities, peers, and teachers while moving and being immersed in the real world. Learners can choose when, where, and what they want to learn.

Even though mobile learning has had a close relationship with other types of learning, the literature has indicated that mobile learning differs from other types of learning. Traxler (2005a) and Laouris and Eteokleuous (2005) defined the central characteristics of mobile learning, many of which distinguish mobile learning from electronic learning. Characteristics that Traxler (2005a, 264) defined are spontaneous, private, portable, situated, informal, bite-sized, light-weight, context aware and interactive, personalized, and connected. The

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3 Advantages such as freedom of choice regarding when, where, and how studying occurs as well as access to diverse materials and feedback.

characteristics defined by Laouris and Eteokleuous (2005) are similar: mobile, objects, spontaneous, connected, networked, lightweight, situated learning, informal, realistic situation, constructivism, situationism, and collaborative. Crompton (2013b, 50) compared traditional learning, electronic learning, and mobile learning (see TABLE 8) and argued that mobile learning needs a theory of its own and that the fields of electronic learning and mobile learning should be separated, especially in terms of learner experience and attributes provided through the field of learning (Crompton 2013b, 50–51). Also, Traxler and Koole (2014, 292) argued that mobile learning needs a theory that is based in its own terminology.

TABLE 8 Comparing traditional learning, electronic learning, and mobile learning (Crompton 2013b, 50)

	Traditional learning	Electronic learning	Mobile learning
Time	Often constrained by formal school hours	Constrained to time spent in front of computer, but can occur at any time of day	No time constraints; learning can take place anywhere you can carry and use a mobile device at any time of day
Personalized	Limited in all aspects of differentiation and concepts taught	Some personalization, with a choice of programs and concepts to be taught, but computers are typically shared and non-personalized	Personalization through applications, concepts, and often the ownership of devices modified for the user
Private learning	Not private	Typically private	Private
Context	Highly limited to a set location and framework	Various locations, although still tied to specific locations and milieus	Learning can take place in numerous environmental and social settings, where wireless access can be obtained
Formal/informal	Formal	Formal and informal	Informal and can also be formal
Socio-connectivity	Connections made to those in direct environment	Virtual connectivity to the networked world	Connections made to those in the direct environment and those networked
Spontaneity	Not spontaneous	Partially spontaneous	Highly spontaneous

All these comparisons (Traxler 2005a; Laouris & Eteokleuous 2005; Crompton 2013b) suggest that mobile learning is more flexible, personalized, and spontaneous than traditional learning and electronic learning. Learning can occur anytime and anywhere, and terms such as “when I want”, “wherever I want”, and “however I want” specify the requirements, interactions, and communications of mobile learning (Laouris & Eteokleuous 2005).

The separation of mobile learning from ubiquitous learning and blended learning is somewhat more challenging because blended learning and ubiquitous learning encompass mobile learning. Mobile learning, for instance, can be seen as one way in which a teacher can blend course content. El-Mowafy, Kuhn, and Snow (2013) considered mobile learning to be one component of the blended learning approach and argued that blended learning that combines traditional learning with electronic and mobile learning can improve the understanding of theoretical principles; thus, students can gain knowledge and develop technical, practical, and professional skills. Also, ubiquitous learning encompasses mobile learning. However, ubiquitous learning is possibly even more pervasive and more sensitive to a learner’s location and situation than mobile learning. Yahya, Ahmad, and Jalil (2010, 123) compared ubiquitous learning, mobile learning, and electronic learning (see TABLE 9).

TABLE 9 Comparing ubiquitous learning, mobile learning, and electronic learning (Yahya, Ahmad & Jalil 2010, 123)

	Ubiquitous learning	**Mobile learning**	**Electronic learning**
Concept	Learn the right thing at the right place and time in the right way.	Learn at the right place and time.	Learn at the right time.
Permanency	Learners can never lose their work.	Learners may lose their work. Changes in learning devices or learning on the move will interrupt learning activities.	Learners can lose their work.
Accessibility	System access via ubiquitous computing technologies.	System access via wireless networks.	System access via computer network.
Immediacy	Learners get information immediately.	Learners get information immediately in fixed environments with specified mobile learning devices.	Learners cannot get information immediately.

(continues)

TABLE 9 (continues)

	Ubiquitous learning	Mobile learning	Electronic learning
Interactivity	Learners' interact with peers, teachers, and experts effectively through the interfaces of u-learning systems.	Learners can interact with peers, teachers, and experts in a specified learning environment.	Learners' interaction is limited.
Context-awareness	The system can understand the learner's environment via database and sensing the learner's location and personal and environmental situations.	The system understands the learner's situation by accessing the database.	The system cannot sense the learner's environment.

The comparison in TABLE 9 indicates that the differences between ubiquitous learning and mobile learning are rather subtle. Overall, mobile learning can be seen as one method of extending traditional teaching and learning with diverse personalized contents and flexible and spontaneous interactions across diverse contexts. The trend in technological development has been toward even greater mobility and therefore mobile devices today have almost the same capabilities as personal computers, but in a smaller size (Crompton 2013a, 11–12). Hence, present-day mobile devices give a learner an opportunity to gain knowledge, skills, and experiences in different contexts, with even more flexibility.

3.3 Underlying Theories and Paradigms for Mobile Learning

Mobile learning appears to have very diverse theoretical perspectives and approaches (see Keskín & Metcalf 2011; Viberg & Grönlund 2012). In a systematic analysis of the literature, Viberg and Grönlund (2012) found a large number of different approaches and theories employed in mobile learning research. However, most of these approaches and theories were discussed in one paper and therefore evidence of cumulative use of theory was lacking. Traxler (2009a, 10) stressed that mobile learning theory is problematic because mobile learning is an inherently noisy phenomenon for which context is everything and confounding variables abound. Traxler (2009b, 5) further argued that if theory is generated by abstracting upward from practice and experience, then mobile learning has been too fragmented and has not yet reached the critical mass of experience and practice to justify such abstraction.

Viberg and Grönlund (2012, 11) emphasized that the theories and models applied in mobile learning most often originate from previous theories of learning like constructivism and situated learning theory. Keskín and Metcalf (2011, 202), in turn, argued that current mobile learning theories include behaviorism, cognitivism, constructivism, situated learning, problem-based learning, context awareness learning, socio-cultural theory, collaborative learning, conversational learning, lifelong learning, informal learning, activity theory, connectivism, navigationism, and location-based learning.

Nevertheless, it is important to acknowledge that learning theories that were relevant in the past may have limited application in current technology enhanced environments (Stoerger 2013, 474–475). According to Siemens (2004), behaviorism, cognitivism, and constructivism are the three broad learning theories most often used when developing instructional environments. However, Siemens (2004) also emphasized that these theories were developed when learning was not affected by technology. Also, Moura and Carvalho (2013, 58–69) stressed that most of the current learning theories cannot explain mobile learning because they are based on the assumption that learning happens in a classroom and that learning is mediated by a teacher. Similarly, also Herrington et al. (2009, 2) stressed:

> Adopting more recent theories of learning has the potential to exploit the affordances of the technologies in more valuable ways.

Thus, learning theories seek to explain and describe the complex processes of how individuals learn (i.e., how individuals acquire knowledge and skills through different actions or interactions). These theories and conceptions of learning have changed over time. In the early 20th century, learning was comprehended mainly as the transfer of knowledge and information from the teacher to students. More modern learning conceptions see learning as an individual quest for meaning and relevance through interpersonal communication, questions, challenges, and discussion. Recently, learning has been understood as more than just recall of facts or correct procedures; it is now understood as being a social activity as much as an individual activity. (Edgar 2012; Choudhary 2008.)

Basically, learning theories can be classified under learning paradigms such as behaviorist, cognitivist, constructivist, humanistic learning paradigm, and similar categories (Leonard 2002). Therefore, the following subchapters discuss five theory-based categories (i.e., behaviorist, cognitivist, constructivist, humanistic, and connectivist) that are often connected with mobile learning.

3.3.1 Behaviorist Learning Paradigm

A behaviorist paradigm draws from the early behaviorists' work, such as Skinner's work on operant conditioning and behaviorism in the 1930s (Naismith et al. 2005, 10). Skinner stressed that behavior is more likely to recur when it has reinforcement. Therefore, positive reinforcement strengthens any behavior that produces it and, in turn, negative reinforcement strengthens any behavior that reduces or terminates it. (Skinner 1974, 46.) Thus, in a behaviorist learning paradigm, learning is defined as a change in behavior that can be facilitated through the reinforcement of a specific stimulus and response (Naismith et al. 2005, 10). In addition, the learner is considered as being reactive to conditions in the environment (Ertmer & Newby 1993, 48). Therefore, behaviorism does not concern itself with the learner's internal mental states, constructs, or symbols; neither is it concerned about whether an individual or a social human need is met. Put simply, behaviorism is concerned with learning outputs with a set of single events controlled by the stimulus response mechanism. This means that instructors drive specific behavioral outcomes from learners through a defined set of learning objectives. (Leonard 2002, 16.)

Behaviorist learning theory has received a lot of criticism because it ignores the cognitive processes and concentrates only on visible behavior. Therefore, it is generally agreed that behavioral principles cannot explain the acquisition of higher level skills or skills that require a depth of processing, such as language development and problem solving. (Ertmer & Newby 1993, 49; Schunk 2012, 114.) The cognitivist paradigm replaced the behaviorist paradigm in the 1960s. However, despite a move away from the behaviorist perspective, in many cases behaviorism is still a dominant force in how learners are taught (Leonard 2002, 16) and numerous technological learning systems still rely on the behavioristic approach (Naismith et al. 2005, 11).

3.3.2 Cognitivist Learning Paradigm

In contrast to behaviorism, the cognitivist paradigm focuses especially on the learner's inner mental activities. Because the emphasis is on mental structures, cognitive theories are considered more appropriate for explaining complex forms of learning, such as reasoning, problem solving, and information processing. In cognitivist learning, knowledge acquisition is described as a mental activity that entails internal coding and structuring by the learner and, therefore, the learner is comprehended as an active participant in the learning process. (Ertmer & Newby 1993, 51.) Cognitivists believe that learning results from organizing and processing information effectively (Jordan, Stack & Carlile 2008, 36). Therefore, information should be organized such that learners can connect new information with existing information in a meaningful way (Ertmer & Newby 1993, 53).

Names associated with the cognitivist learning paradigm are Piaget and Bandura. Jean Piaget was one of the most influential cognitive psychologists. Piaget (1936) conducted a systematic study of cognitive development, which for Piaget meant a reorganization of the mental process as a result of biological maturation and environmental experiences. According to Piaget (1936, 362–372), experiences are necessary for development, while Albert Bandura (1989) emphasized that people function as contributors to their own motivation, behavior, and development within a network of reciprocally interacting influences.

Also, Noam Chomsky was a pioneer of the cognitivist paradigm. He claimed that in a child's language learning, reinforcement, casual observation, and curiosity are important factors, but that equally important are the child's capacity to generalize, hypothesize, and process information in a variety of special and complex ways. (Chomsky 1967.) Chomsky (1967) also added that information processing in particular should be described and understood to better comprehend learning. Hence, the cognitivist paradigm is concerned with learning inputs, outputs, and an accurate depiction of the internal processing of the human mind. Therefore, the cognitivist paradigm is still an influential force in delineating how humans think, learn, transmit information, and solve problems. (Leonard 2002, 29–30.)

3.3.3 Constructivist Theories

Also, constructivist theories emerged during the 1960s and 1970s (Naismith et al. 2005, 12). Unlike behaviorism, constructivism places learners in an open-ended learning environment in which they build their own meaning from knowledge and content. Therefore, constructivism is a learner-centered paradigm. (Leonard 2002, 37–38.) Also, environmental factors are seen as critical because the specific interaction between the learner and environment is what actually creates knowledge. Thus, in constructivist learning, it is important for learning to occur in realistic settings and for the learning tasks to be relevant to the learner. (Ertmer & Newby 1993, 56.) Constructivist learning environments, therefore, should provide rich experiences that encourage students to learn. The aim is to teach big concepts using student activity, social interaction, and authentic assessments. (Schunk 2012, 275.) Thus, learners are encouraged to be active constructors of knowledge at the same time they are embedded in a realistic context and offered access to supporting tools like mobile devices (Naismith et al. 2005, 2).

Piaget's and Vygotsky's theories, in particular, can be seen in the background of constructivist learning theories. Both Vygotsky's and Piaget's theories combine intrapsychic[4] and interpsychic[5] mechanisms. They both also view actions as starting blocks for further development. However, they understand these actions somewhat differently. Piaget sees action as a natural event taking place in the natural environment. Vygotsky, in contrast, sees action as a rich and meaningful human act constructed by history and society. (Tryphon & Vonèche 1996, 9.) Piaget's theory of genetic epistemology concentrates on the individual in learning and Vygotsky's cultural-historical theory especially focuses on the social in learning. Thus, constructivist learning theories can be separated into cognitive constructivist and social constructivist approaches. Social constructivist theory originates in Vygotsky's perceptions. Vygotsky (1962, 19–20) stressed that it is impossible to separate learning from its social context and argued that the true direction of the development of

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4 Intrapsychic refers to the individual's inner psychic processes.
5 Interpsychic refers to the psychic processes that involve relations between people.

thinking is not from the individual to the socialized, but from the social to the individual.

Both Piaget and Vygotsky also advocated inquiry-based instruction. Inquiry-based instruction means that the student perceives a problem, constructs a mental model to solve the problem, and then forms a solution. (Pass 2004, 103–110.) Hence, in constructivist learning, learner inquiry and discovery, learner autonomy, and self-motivation are critical elements of a successful learning process and therefore the teacher serves as a catalyst or coach (Leonard 2002, 37–38). The goal of constructivist learning is not that the learners know particular facts but rather that the learners elaborate on and interpret information (Ertmer & Newby 1993, 56).

3.3.4 Humanistic Learning Paradigm

The humanistic learning paradigm also emerged in the 1960s, originating primarily in the work of Abraham Maslow and Carl Rogers (Leonard 2002, 86). The core of Maslow's theory is basic human needs. Maslow (1943) argued that people are driven to satisfy certain needs and only when one need is fulfilled does a person seek to fulfill another need. Maslow's (1943) theory begins with basic physiological needs such as food and sleep and moves all the way to self-actualization[6]. Roger's theoretical views, in contrast, focus on the goal of achieving self-direction[7] and personal choice that leads to individual growth and maturation. Thus, the humanistic learning paradigm especially prioritizes the learner's self-direction, inner motivation, and self-reflection. (Leonard 2002, 86.) Hence, people tend to live based on the perceptions and values they have developed. Each learner constructs a unique and idealized world comprising the people, behaviors, values, and benefits that motivate and drive him or her. (Sullo 2007, 9–10.)

Motivation is seen as the aspect that guides and directs an individual's behavior toward reaching a specific goal. Motivation is an internal state that arouses individuals to action, directs them to certain behaviors, and assists them in maintaining that arousal and action. Motivation increases effort and energy expended toward a specific goal as well as the initiation of and persistence in activities. It also enhances cognitive processing and generally leads to increased performance. Motivated learners are happier, feel better about themselves, and learn more. (Wiseman & Hunt 2008, 43–87.) Therefore, motivation plays a central role in human learning (Westwood 2004, 30). Garrison (1997) argued that learner motivation is particularly determined by valence and expectancy. Valence, according to Garrison (1997), refers to the attraction to particular learning goals. Factors that affect the valence in an educational context are personal needs, values, and preferences. Needs and values especially reflect the reasons for persisting in a learning task. Expectancy,

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[6] Self-actualization means realizing and utilizing one's full potential: "What a man can be, he must be" (Maslow 1943).

[7] Self-direction denotes dictating one's own behavior.

in turn, according to Garrison (1997), is composed of personal and contextual characteristics that influence goal achievement (e.g., competency, skills, abilities, knowledge, institutional resources).

Another important view of humanistic learning is self-direction which means that the learner is able to dictate his or her own learning behavior (i.e., take initiative and responsibility for one's own learning). Garrison (1997) argued that taking responsibility to construct personal meaning is the essence of self-directed learning. He added that taking responsibility for one's own learning does not mean making decisions in isolation. Instead, teachers should create the educational conditions that will facilitate self-direction (e.g., negotiate a shared purpose, provide external and internal resources, and create conditions in which learners can monitor their thoughts and behavior). The self-directed learning model introduced by Garrison (1997) integrates self-actions such as managing and monitoring one's progress as well as motivational dimensions.

3.3.5 Connectivism: A Learning Theory for the Digital Age

Connectivism, introduced by George Siemens (2004), is a learning theory especially for the digital age. It aims to provide insights into the learning skills and tasks needed in a digital era. Connectivism theory integrates the principles of chaos, network, complexity, and self-organization theories. It also acknowledges that learning is no longer an internal, individualistic activity and that the ways in which people work and function are altered when new tools are utilized. (Siemens 2004.) The approach emphasizes the importance of information and linking it to the right people. Efficient information navigating and filtering are particularly important. From this point of view, mobile devices offer the ability to connect with information and resources when the need is essential. Learning connections can take place in the classroom, at home, or on the go whenever needed. (Stoerger 2013, 475.)

3.4 Practices of Mobile Learning

Various theories, models, and paradigms of teaching and learning can be used to structure and support mobile learning practice in an educational context (Low & O'Connel 2006). Each, of course, offers different perspectives and practices to mobile learning. Naismith et al. (2005, 19) stated that a blended approach to mobile learning is necessary because successful and engaging mobile learning activities draw on a number of theories and practices. Also, Ritchie and Baylor (1997) concluded that the most successful technology-based learning implementation combines learning strategies based on behaviorist, cognitivist, and constructivist learning theories within a situated learning environment relevant to the student's needs. Patten, Arnedillo-Sánchez and Tangney (2006, 304) argued that educationally appropriate mobile learning applications are built on a combination of various learning theories and principles (e.g., collaborative, contextual, and constructivist principles). Herrington and Herrington (2007) stressed that concepts such as situated learning and authentic learning are useful for guiding the design of technology-supported learning environments for higher order learning.

Educational technologies like mobile devices in general can be employed in a wide variety of ways to enhance learning in both formal and informal education. The educational technology itself usually does not determine the way in which it is used and applied to support teaching or learning (Passey 2014, 34–35). Thus, technology-based learning activity does not exist ready-made in technology or software. The same technology or software can generate different activities and experiences in different learning environments. Therefore, technology-based learning activities are always constituted through a situated interaction of learners, teachers, and technologies. (Mercer & Littleton 2007, 27.)

Hence, what is noteworthy is that educational technologies vary widely; some are more teacher-centered (e.g., interactive whiteboard), enabling teachers to convey knowledge to students more easily, and some are more learner-centered (e.g., mobile devices) enabling students to construct their own understanding and knowledge. A wide variety of approaches to the different technologies can be utilized in an educational context. (Passey 2014, 34–35.) Basically, mobile learning can be seen as a method for extending and blending teaching and learning. It is important to perceive mobile learning as part of a learning continuum that includes multiple learning tasks and multidisciplinary learning (Cinque 2013, 222). Tétard, Patokorpi and Carlsson (2008, 6), for instance, highlighted that mobile learning is not an isolated activity or phenomenon; instead, it should be seen as part of other forms of education.

Sharples (2013) argued that the enhanced levels of the mobile device can be seen as two ends of a dimension (FIGURE 5). At one end are the systems that enhance traditional classroom learning and at the other end are systems that enhance informal everyday life learning.

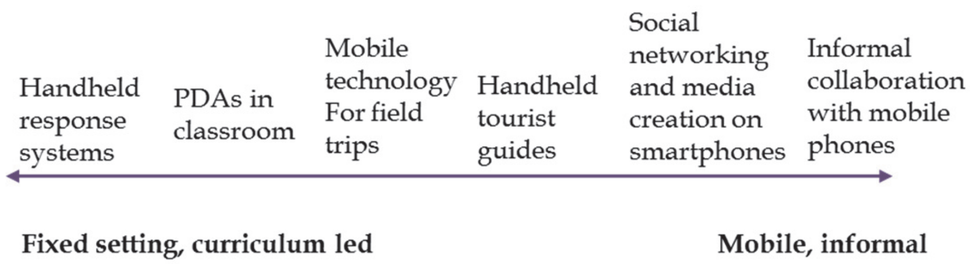

FIGURE 5 Types of mobile learning (adapted from Sharples 2013)

Thus, mobile technologies can be integrated in various ways in and outside the classroom to enhance and extend learning and therefore can promote innovative teaching practices. It has been suggested that innovative teaching practices such as student-centered pedagogies, extending learning beyond the classroom, and integrating information and communication technology into teaching and learning can support learners' development of the skills they will need in future life and work (Shear, Gallagher & Patel 2011, 12). Thus, educational technology, like mobile technology, can also provide skills development in areas such as communication, problem solving, and critical thinking, which are considered important skills for future life and work (Binkley et al. 2012, 18–27). TABLE 10 summarizes some of the mobile learning possibilities.

TABLE 10 Mobile learning possibilities (adapted from ADL Mobile Learning Handbook 2011)

Mobile Learning Possibilities	
Learning Modules • Just-in-time learning • Micro learning • Reach-back/review	**Performance Support** • On-the-job support • Alerts • Reminders • Procedures • Job aids • Forms and checklists • Decision support • Information-/knowledge bases • Personal organizers
Access to Information, Education and References • Field guides • Presentations • Podcasts/vodcasts • Updates • Audio/video recordings	**Collaboration and** • Coaching • Conferencing • Feedback • Mentoring • Social networking
Assessment • Quizzes • Evaluations • Tests • Surveys or polls • Reporting • Certification	**Innovative Approaches** • Games and simulations • Location-specific content • Augmented reality • Contextualized learning • Spaced learning
User-Generated Content • Note taking • Transcription • Translation • Photos • Videos • Audio capture • Blogs and microblogs • Wikis • Learning journals • Portfolios	**E-books** • Textbooks • Papers • Manuals or reference guides

The following subchapters will take an activity-centered perspective, considering practices against theories. TABLE 11 summarizes mobile learning examples linked with learning theories. These examples will also be discussed in more detail in the following subchapters.

TABLE 11 Theory-based examples of mobile learning practices

Theory	View of the Learning Process	Examples with Mobile Technologies
Behaviorist	Change in behavior and observable actions facilitated through the reinforcement of a specific stimulus and response.	Drill and feedback activities/classroom response systems (subchapter 3.4.1)
Cognitivist	Learning results from organizing and processing information effectively.	Performance support (subchapter 3.4.2).
Constructivist	Learners actively construct new ideas or concepts based on both their previous and current knowledge.	Approaches like experiential learning (subchapter 3.4.3), participatory simulations (subchapter 3.4.4), discovery learning (subchapter 3.4.5), collaborative learning (subchapter 3.4.6), situated learning (subchapter 3.4.7) mediated by mobile devices.
Humanistic	A personal act to fulfill potential.	Self-directed learning (subchapter 3.4.8)
Connectivistic	Connecting, navigating, and filtering specialized nodes or information sources.	Social networking and media creation (subchapter 3.4.9).

3.4.1 Drill and Feedback Activities

Using mobile devices to present learning materials, obtain responses from learners, and provide appropriate feedback fits within the behaviorist paradigm (Naismith et al. 2005, 10). These types of activities can also be called drill and feedback or drill and practice activities. Drill and feedback activities are especially suitable for repetitive practice and small tasks such as the memorization of vocabulary or rehearsing mathematical skills. Drill and feedback activities offer advantages such as the gathering of data to track the progress of each student and the tailoring of content and feedback to suit particular curriculum areas. Mobile devices in drill and feedback activities provide anonymity and speed aggregating and displaying collective understanding, as exemplified by classroom response systems. (Naismith et al. 2005, 11; Hanewald & Ng 2011, 6.)

Lam et al. (2011) implemented a web-based classroom response system that used mobile phones instead of traditional handheld transmitters called clickers. The study indicated that a mobile device-based classroom response system promoted teacher-student interaction and helped students think and apply knowledge in problem solving. Also, Rikala (2011) studied a mobile device-based classroom response system called InSitu in her master's thesis. The InSitu system was developed at the Department of Mathematical Information Technology at the University of Jyväskylä (see Puranen, Helfstein & Lappalainen 2009). Rikala (2011) indicated that the mobile-based classroom response system motivated and activated students. Interaction increased during the lessons and everyone had an opportunity to have their opinions heard. The system also helped students clarify the issues on which they should focus as they received instant feedback about their progress. Rikala (2011) also discovered that especially in mass lectures, a classroom response system can be an easy way to increase students' participation and increase the teacher's comprehension regarding students' thoughts and misconceptions.

Kalloo and Mohan (2012), in turn, explored the mobile math system. That system was designed to encourage learners to practice certain mathematical skills. The system's features were designed based on strategies derived from teaching mathematics traditionally in the classroom. Kalloo and Mohan (2012) indicated that students were capable of improving their performance and students were excited about using mobile devices for learning. However, the study indicated that the mobile application did not have a significant impact on those who were learning the content for the first time.

3.4.2 Cognitive Performance Support

As stressed in subchapter 3.3.2, the cognitivist learning paradigm believes that to achieve the most efficient learning, information must be presented in an organized manner so that learners are able to connect new information with existing information in a meaningful way. Some researchers have studied mobile learning systems from the perspective of cognitive load[8] and especially how different components (e.g., content, device, methods) should be designed to support and promote a learning process. Hwang et al. (2010) discovered that students' cognitive load can be decreased if the mobile learning systems and the learning activity are appropriately designed. In their study, the PDA-based mobile learning system acted as a tutor by showing supplementary materials and asking relevant questions during a tour-based local culture learning activity.

Also, scaffolding[9] has been examined in many mobile learning studies. Chen, Chang, and Wang (2008) adopted a mobile short message service to transfer helpful information, reminders, and facilitative peer support to scaffold students' learning. The students were provided with an information awareness reminder mechanism through mobile devices to support their learning in the class. The study indicated that students' test results, task-accomplished rate,

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8 Cognitive load refers to the capacity and load of working memory.
9 Scaffolding means a variety of instructional techniques that support and facilitate the learning process.

and learning-goal-achieved rate can be improved with the support of mobile devices.

Also, Shih, Chuang, and Hwang (2010) implemented an activity where mobile devices and wireless communications guided elementary students to learn. The students were situated in both the real world and the virtual world to extend their learning experiences. In the class session, the teacher introduced the historic background of the Peace temple, local cultures, and religions as well as other relevant information relating to an upcoming field trip. In the field, the students used mobile devices to explore the temple. They visited different spots where the mobile device guided and presented hints for the students to observe certain architecture and sites. The students also took notes and interviewed people. Finally, the students synthesized and categorized the data collected in the field and constructed reports that they shared with their classmates. Shih, Chuang, and Wang (2010) indicated that students' cognitive learning achievements significantly improved because mobile devices provided students with a customized learning pace and process and students could get individual attention and guidance during the activity in the field.

Hence, from the learner's point of view, it is important to receive sufficient feedback and guidance during the learning process. This kind of support can increase learners' confidence and competencies as well as help them cope with arising difficulties (Nordin, Mohamed & Melor 2010, 134).

3.4.3 Experiential Learning Activities

Kolb's (1984) experiential learning model aligns with the constructivist learning theory. The experiential learning model aims for learner inquiry and discovery. Kolb's (1984) model particularly connects experience, perception, cognition, and behavior. Experience plays a central role in the learning process. Experience is a basis of observation and reflection. Learners create concepts that integrate their observations into theories and then use these theories to make decisions and solve problems.

Chen et al. (2008) strengthened Kolb's (1984) experiential learning cycle with a challenge approach. At the beginning of the lesson, the teacher presents the background of the concept as well as the actual challenge related to the concept to be learned. In the experience stage, students are equipped with mobile devices to perform a set of activities in the context of the learning objectives. In the next stage, students reflect on their experience. For instance, students can generate a report with mobile devices and upload it to an online portal. In the report, students can reflect on and generalize about what they learned during the experience. Then students can make presentations or artifacts to represent their ideas. Finally, students are also asked how they would apply what they have learned to similar or different situations. Chen et al. (2008) indicated that by using the challenge approach the learning was more student-centered. The mobile application allowed the students to construct knowledge easily. For example, students observed and recorded different types of packaging, collected data on plastic bags, and interviewed people in a local supermarket about their perspectives on the environment. The mobile device extended learning outside the traditional classroom; it amplified students' thinking by supporting and guiding their thought processes throughout the field trip.

3.4.4 Participatory Simulation Activities

Another example of the implementation of constructivist principles with mobile devices is participatory simulations. In participatory simulations, students do not only watch the stimulation; instead, they are part of the simulation. Students with networked devices are key parts of the dynamic system and their actions affect the simulation. Learners are engaged in the learning process and they can immediately see the effect of their actions on the system as a whole. (Naismith et al. 2005, 13; Hanewald & Ng 2011, 6.)

Collela (2000) described a study in which learners took part in a participatory simulation. The subject of the simulation was the spread of a virus. Small and wearable computers called thinking tags mediated the simulation. At the beginning, the students were given a challenge: Meet as many people as you can without getting sick. Students were also informed that one of the thinking tags contained a virus. During the simulation, students moved around and met other people. They could stop meeting people anytime they wanted by simply turning off their thinking tag. Students were given an opportunity to experience and explore the behavior of the virus and test their own experimental hypotheses; they collaborated and interacted when trying to explore how the virus spreads. Hence, simulation activity supported collaborative scientific investigation.

3.4.5 Discovery Learning Activities

Discovery learning is a constructivist-based approach in which the key idea is that learners are more likely to remember concepts if they discover them on their own, apply them to their own knowledge base and context, and structure concepts to fit their own background and life experiences. Thus, learners are actively involved in shaping content. (Leonard 2002, 54.)

Seol, Sharp, and Kim (2012) examined the use of a mobile application to promote scientific discovery learning. Fourth and fifth grade students used a customized eBook Maker mobile application to individually explore the scientific phenomena from their daily life, record their investigations (e.g., by taking pictures, recording audio, writing notes), and create mobile documents. After two weeks, students presented their own discoveries by reporting the topic of their investigation, how they chose to explore the phenomena, the most interesting thing they learned during the process, and their conclusions regarding the findings of their own investigation. The study indicated that the mobile application helped students select their own topics, search relevant information from a variety of sources, and come to their own conclusions. Seol, Sharp, and Kim (2012) also argued that the use of a mobile application in the discovery learning process can help students build logical and scientific argumentation skills.

3.4.6 Collaborative Learning Activities

Collaborative learning strategy has its basis in Vygotsky's social development theory and therefore can be considered a constructivist strategy. A collaborative learning strategy sees that learning results occur through the continuous interactions among learners. (Leonard 2002, 30–31.) Thus, collaborative learning interactions among peers are considered significant. However, the teacher plays a significant role in organizing fruitful collaboration. This means that collaboration is not necessarily accomplished by assigning students to groups and asking them to work together. First, the task must be appropriate to the capabilities of the learners. Second, the task should be structured so that learners must work together cooperatively. (Nussabaum et al. 2009.)

Thus, the collaborative learning approach is based on the notion that individuals learn through conversations with each other, by sharing understandings of ideas and concepts of the world around them. Mobile devices are well suited for collaborative learning. Collaboration can take place through the devices as well as through the other learners. Mobile devices also allow easy access, data sharing, and enhance the possibilities for communication. (Naismith et al. 2005, 15–17; Hanewald & Ng 2011, 7.) At their best, mobile devices can enhance and encourage collaboration (Rikala & Kankaanranta 2012). Frohberg, Göth, and Schwabe (2009, 307), however, argued that communication and collaboration in general have played a surprisingly small role in mobile learning projects and pilots.

Alvarez, Alarcon, and Nussbaum (2011) implemented collaborative learning activities supported by mobile devices. They used the CollPad script originally introduced by Nussbaum et al. in 2009. The idea behind the CollPad script is to encourage social interactions toward constructing a shared understanding of open-ended tasks. Learners are randomly assigned to small groups. After groups are organized, the teacher gives the learners an open ended task. First learners work individually. Then the system shows all group members a visualization containing their individual answers and the group has to agree on one of the available answers or write a new answer collectively. After this, the teacher can start a whole-class discussion. The teacher picks random students from each group, who must defend the answer submitted by their group. When the whole class agrees on a final response, the problem can be closed. In the collaborative mobile learning framework introduced by Alvarez, Alarcon, and Nussbaum (2011), the learning activities occur in the classroom. However, Alvarez, Alarcon, and Nussbaum (2011) argued that the framework could be extended to support scenarios that leverage user mobility, such as learning activities that combine outdoor and indoor locations, activities based on augmented reality, and pervasive learning applications.

Also, Laru (2012) explored how to facilitate mobile computer-supported collaborative learning. His study indicated that successful collaboration requires both careful design of the learning environment for group interaction and provision of scaffolding as well as support from the teacher. Thus, pedagogically grounded instructional design is needed to put mobile technologies into effective collaboration tools. Laru (2012) also argued that simple tools and rich practices are particularly important.

Leinonen et al. (2014) argued that mobile applications that are designed to correspond to collaborative learning paradigms appear to be limited. Therefore, they designed two mobile applications that were specifically designed for student-centered and collaborative learning where reflection is an important part of the learning process. Their research indicated that mobile applications may have potential to foster reflection on classroom learning.

3.4.7 Situated Learning Activities

Situated learning theory is greatly influenced by Vygotsky's social development theory and therefore can be considered a constructivist approach (Leonard 2002, 174). Lave's and Wenger's situated learning theory from the 1990s views learning as not merely the acquisition of knowledge by individuals, but as a process of social participation (Naismith et al. 2005, 13). Lave and Wenger stated (1991) that the situated nature of learning, remembering, and understanding is a central fact. Therefore, learning is an integral and inseparable aspect of social practice. The focus of a situated paradigm moves from the individual as a learner to learning as participation in a social world and from the concept of cognitive processes to the more encompassing view of social practice. (Lave & Wenger 1991.) Thus, the situational learning paradigm focuses entirely on the learning experience as a shared, social, and almost unintentional learning event (Leonard 2002, 174). Situated learning theory also posits that learning and cognition are situated and that activity and perception occur prior to conceptualization. Knowledge is part of the activity, context, and culture in which it is developed and used. For this reason, authentic activities are considered important. (Brown, Collins & Duguid 1989.) Hence, situated learning requires knowledge to be presented in authentic contexts and learners to participate within a community of practice (Naismith et al. 2005, 13).

Three approaches, in which mobile devices can be used within the situated paradigm, are appropriate: problem-based learning, case-based learning, and context-aware learning (Hanewald & Ng 2011, 6–7). In a problem-based approach, the focus is on organizing the curricular content around problem scenarios to encourage students to engage in the learning process (Savin-Baden & Howell 2004, 3). The problem-based approach is an instructional and learner-centered approach. Also, collaboration is seen as an essential part of the learning process. Learners conduct research together, integrate theory and practice, and apply knowledge and skills to develop a solution to a defined problem. (Savery 2006.) A problem-based learning activity can be built in a mobile learning environment where the learning process starts by presenting students with an inspiring problem through the mobile device. During the activity, students discuss, observe, collect information, and make assumptions. The mobile learning system supports and assists students in completing the learning task and developing a solution to a problem. (Li & Chun 2011.) Cahill et al. (2011) developed a Zydeco system to support inquiry and data collection. During a field trip, students explored a museum and used a mobile application to collect data to respond to the question given to them. After the field trip, the students reviewed, reorganized, analyzed, and synthetized their findings to create a scientific explanation for the question. The authors indicated that the mobile application encouraged collaborative sense making and increased student engagement.

Case-based learning is similar to problem-based learning, but more flexible and open ended, and it can be used especially as a catalyst for class discussion (Hanewald & Ng 2011, 6–7). Scott et al. (2010) utilized mobile devices in a case-based learning scenario to enhance medical students' learning. The learning activity contained a case description of an adolescent patient with anorexia nervosa, interactive true/false and checkbox-style questions with automatic feedback, reading materials, web links, and references. Scott et al. (2010) highlighted that the students regarded the study as more self-directed because all the required materials were at their fingertips whenever and wherever the students needed them.

The third strand, context awareness, refers to gathering information from the environment or making available activities and content that are relevant to the environment. Mobile devices are especially well suited for context-aware applications because they are available in different contexts and therefore can support and enhance a learning activity by allowing the learner to maintain his or her attention on the world and by offering appropriate assistance when required. (Naismith et al. 2005, 14.) An example of a mobile system and situated learning in an authentic context is the Ambient Wood project by Rogers et al. (2002). In the Ambient Wood project, children explored and reflected upon biological processes by using a variety of devices and multi-modal displays. The learning experience was structured into three distinct stages: (1) exploring and discovering, (2) reporting, consolidating, and hypothesizing, and (3) experimenting and reflecting. The learning experience also included collaboration and interaction among students. The aim of the activity was to augment the physical environment with various forms of digital information so that children's interaction and perceptions would be extended in surprising and unusual ways. The goal was to get children to take part and learn more about scientific inquiry through discovering, reflecting, and experimenting. The study indicated that the activity was highly engaging and provided novel learning experiences for the children.

Another example of mobile learning in an authentic situated context is the butterfly-watching system implemented by Chen et al. (2004). They created an outdoor learning activity that was mediated through mobile technology. The mobile system supported independent learning by enabling the butterfly observer to identify the family, name, ecology, and behavior of a certain butterfly. The observer could also take notes during the activity and upload those notes to a computer for later review. Content-based image-retrieval techniques also allowed the user to acquire information on butterflies more quickly and easily. A similar system has also been implemented for bird-watching; Chen, Kao, and Sheu (2003) indicated that the children who used the bird-watching system improved their learning outcomes.

3.4.8 Supporting Self-Directed Learning

Self-direction is viewed as an important aspect in a humanistic learning paradigm (subchapter 3.3.4). Zhang et al. (2010) observed that in a mobile learning activity, learners can have more flexibility in managing their own learning pace. They also observed a shift in classroom behavior. Students became more engaged and motivated and they controlled themselves and managed to complete tasks independently. Thus, mobile technologies can support self-directed learning.

Gaberson, Oerman, and Shellenbarger (2014, 180) argued that mobile learning is a useful tool for self-directed learning because students can access learning materials whenever and wherever they need them. They added that mobile learning can promote student engagement and self-efficacy[10] as well as support diverse learning styles.

The Singaporean project (WE Learn) utilized a mobile learning platform called MyDesk to enhance students' self-directed learning. The platform provides tools that support inquiry-based pedagogy such as concept mapping, drawing, animating, and writing. Overall, the mobile platform enables learners to proceed at their own pace and schedule. A teacher can easily send assignments to students and students can access them anywhere and anytime. (Baker, Dede & Evans 2014.)

Hashim, Ahmad, and Ahmad (2011) developed a mobile system called MOSAD as a revision tool for students. The MOSAD system was developed based on student-centered perspectives to be suited for the learners' ways of studying and learners' environment and to fulfill the lesson requirements. The authors indicated that students who used the system to answer quiz questions achieved better results. They further argued that the mobile system can help students in making revisions in preparation for tests or examinations. Thus, the mobile system afforded students an avenue for self-directed and independent study.

3.4.9 Social Networking and Media Creation

Al-Shehri (2011) applied the connectivism approach to describe how students can communicate and learn language by using mobile phones and social networking. Students used mobile phone technology and Facebook to participate in a collaborative learning experience where connectivist

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10 Self-efficacy refers to a person's belief in his or her ability to complete a task or solve a problem.

implications were adapted to account for different practices in mobile language learning. The students used mobile phones, for instance, to capture materials, edit them, and upload them to Facebook. The students also collaborated via Facebook. The connectivism provided a framework that recognized students' individual differences and backgrounds and delivered meaningful sources of knowledge. The study indicated that students were able to choose learning resources and connections that enhanced their language learning. The approach was also more student-centered as the teacher was not the only source of information. The students collaborated and obtained information from other people and resources. They also learned to identify appropriate and inappropriate information and resources.

3.5 Mobile Learning Activity Design

Although there are many possibilities and ways to integrate educational technologies like mobile devices into teaching and learning (see TABLE 10, 56), current use is still rather teacher-centered and classroom-bound. The unfortunate reality is that the vast majority of classrooms looks the same as they would have 100 years ago. Classrooms are mostly teacher-dominated as the teacher stands at the front of the classroom conveying knowledge. Students sit in rows of desks and answer routine questions and no technologies are anywhere in sight. (Bernard 2013, 210.)

These kinds of traditional, teacher-centered, and classroom-bound practices were, for instance, observed repeatedly in the innovative teaching and learning (ITL) research, which was carried out in seven countries (Kankaanranta & Norrena 2010). Similar kinds of observations were made in research funded by the National Institutes of Health that explored the typical child's schooldays in 2007 in the United States. The study indicated that students spent most of the class time in their seats listening to a teacher or working alone and only a small portion of the activities required group work or fostered social skills and critical thinking. (Toppo 2007.) Thus, primary media for traditional formal classroom learning are face-to-face learning in classrooms and textbooks (Karadeniz 2009, 359). In these traditional classrooms, students often become passive learners, receiving the teacher's knowledge in lecture format. Therefore, this kind of traditional approach is generally called a teacher-centered approach or teacher-centered instruction. (Alexandra 2013, 205.) Teacher-centered instruction is considered a highly structured environment in which the teacher organizes learning tasks, presents material in accordance with his or her objectives, and establishes the time and methods for instruction (Hancock, Bray & Nason 2002, 365).

Recently, student-centered thinking has given rise to increasing interest in the use of a variety of active learning methods that engage learners in the learning process and give responsibility for learning to learners. In student-centered learning, the teacher does not function as the primary source of knowledge in the classroom. Instead, the teacher is perceived as a facilitator or coach who supports students' learning inside and outside the classroom. (Mascolo 2009, 3–27.) Therefore, student-centered instruction involves a less structured classroom setting where students influence the time and the nature of instruction and the organization of learning tasks, as well as participate in an open exchange of ideas. (Hancock, Bray & Nason 2002, 365.)

Despite the increased emphasis on student-centered thinking, the methods of teaching and learning are still in many respects traditional, teacher-centered or directed, and classroom-bound and the active role of the student and benefits from a peer and/or independent learning are too rarely observed (Kankaanranta & Norrena 2010; Osborne & Hennessy 2003). Norris and Soloway (2013, 110), for instance, highlighted that for the most part schools have simply assimilated or integrated ICT into the existing pedagogy and that actually educational technologies like electronic whiteboards and response systems have made teacher-centered instruction and pedagogy even easier. Chen (2008, 72), furthermore, observed inconsistency between teachers' expressed beliefs and their teaching practices. All of the study participants reported high levels of agreement on constructivist student-centered concepts; however, the participants' instruction remained teacher-centered as well as lecture-based and the teachers used technology only to support such instruction. Also, Ferrari, Cachia, and Punie (2011, 103) argued that technologies in classrooms are often employed to reproduce old pedagogies and that textbooks are still the most common and widespread resource for schooling across Europe. They added that teachers mainly prefer conventional technologies and only a few teachers recognize the benefits of interactive, collaborative, and user-led technologies such as mobile devices and digital games. Herrington and Herrington (2007) argued that the current use of mobile technologies in education appears to be predominantly within a didactic, teacher-centered paradigm, rather than a more constructivist environment. The teachers also seem to adopt old pedagogies and the usage of technology essentially involves only content delivery. Therefore, mobile device use, according to Herrington and Herrington (2007), is pedagogically regressive.

Thus, one common mistake that teachers make is to simply automate traditional activities; for instance, students are asked to use a word processor to type a paper once it has been handwritten or to create a PowerPoint presentation. Such changes do not challenge students to study content more deeply and therefore have little or no impact on overall student performance. (Brooks-Young 2010, 5–13.) Moreover, in several cases, mobile devices are used mainly to enhance teachers' own personal productivity, not to enhance students' learning (Abas & Hussain 2013, 590).

Puentedura (2009) classified the ICT usage levels as enhancement (i.e., substitution and augmentation) and transformation (i.e., modification and redefinition) as illustrated in FIGURE 6 (in Substitution Augmentation Modification Redefinition (SAMR) model). Recently, the SAMR model has been utilized with the development of educational applications and especially with mobile devices. At the enhancement level, the technology acts as a direct substitute for the original tool (e.g., worksheets, pen and paper), with only a little functional change or improvement (i.e., texts are read in online versions or notes are taken with a tablet device). The transformation level, in turn, means that technology allows a completely new learning experience and supports student-centered learning. Also, Norrena, Kankaanranta, and Nieminen (2011) proposed a similar kind of classification by dividing ICT use into basic use and higher level use. The higher level use of ICT promotes in-depth integration of ICT. Examples of higher level use are analyzing and integrating information, creating contents, using simulations and animations, and communicating with people outside the school context. Basic use means traditional classroom teaching materials recompensed with electronic materials, multiple-choice tests, information retrieval, use of a word processing program, practicing of skills, and returning of homework or other assignments electronically.

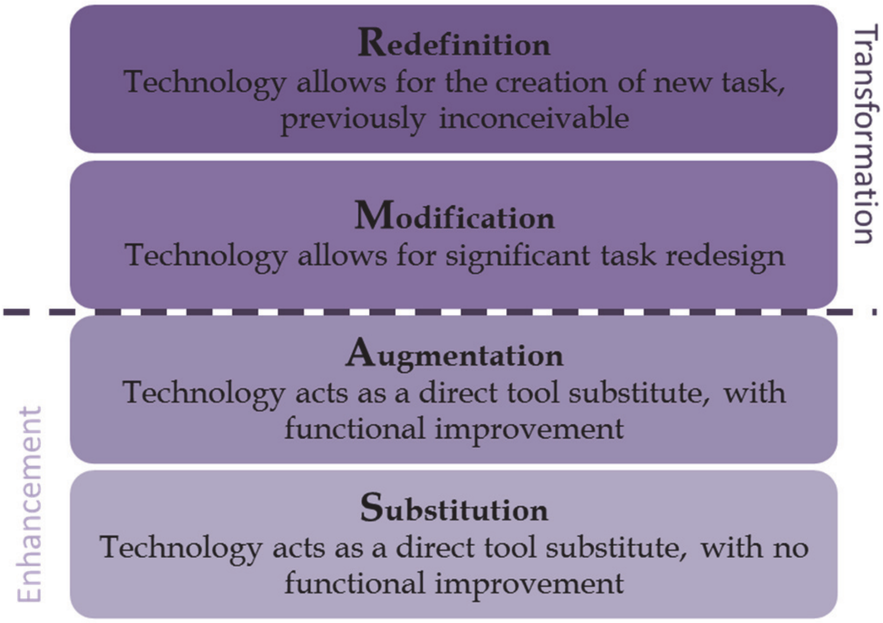

FIGURE 6 SAMR model (adapted from Puentedura 2009)

In many cases, experience has ensured that using technology for technology's sake is not a good use of instructional time and it most likely does not improve student achievement (Pitler, Hubbell & Kuhn 2012, 217). However, many studies have indicated that the new pedagogies and innovative use of technologies in an educational context can offer very promising results from the learning perspective (Conole 2013, 3). Technology-based learning activities, for example, have the potential to provide a highly motivating learning experience for learners through the use of engaging and adaptable material (Clarke 2001, 1).

Several mobile learning studies have indicated that mobile learning can be motivating for learners and can support different learning needs and preferences. Attewell, Savill-Smith, and Douch (2009) suggested that mobile technologies can make learning more convenient, accessible, and inclusive as well as sensitive to the learner's individual needs and circumstances. Attewell, Savill-Smith, and Douch (2009), for instance, described a case in which Sony PSP handheld gaming devices were utilized to re-engage disaffected learners and to improve their numeracy skills. The games were fun for the students, but they were also designed to test their numeracy skills. The learners were more engaged and their retention increased. In another case, learners with learning difficulties and disabilities used mobile devices on a field trip to Manchester's Transport Museum to gather evidence for their portfolios. The mobile devices engaged and supported learning. In a third case, iPod Touch devices were used to send text messages to learners, which motivated them to attend and stay on course. The students were enthusiastic and motivated to complete work on their own using the mobile devices outside the classroom. Technology-based learning activities in general have the potential to provide highly motivating learning experiences for learners through the use of engaging and adaptable material (Clarke 2001, 1). Hence, one major advantage is that mobile technologies allow a teacher to differentiate instruction and actions more efficiently by providing a wider variety of avenues for learning and thus the technologies can be used to accommodate learners' different learning styles and needs.

However, it is important to acknowledge that students' attitudes, expectations, and preferences regarding mobile learning vary. Xie, Zhu, and Xia (2011) investigated college students' mobile learning needs and preferences. Their study indicated that students have different expectations about mobile learning. Some students expected and required more guidance and feedback. Others desired more subject knowledge in various forms. Thus, mobile learning design should take into account different learning needs and preferences to attract and engage learners. Bloem and van Aart (2010) argued that both "smart" and "fun" are sources of human and social satisfaction and motivation. From this point of view, they envisioned a mobile tourist-guide application that combined navigation information and edutainment. Rikala and Kankaanranta (2012) indicated that the focus should be on the learner and the learner's learning needs rather than the technologies; if the focus is too much on technology and the activity is not well planned, it may fail to motivate students and their attention may be diverted to something else or even to so-called multitasking. This observation was made in the mobile learning activity that utilized Quick Response (QR) codes in story trail activity. The contents of the QR code trail were the same in the classroom and in the trail. Also, some technical problems occurred during the trail activity. Therefore, the activity was not interesting enough for the students and the students, for instance, played music on their phones during the trail activity (Rikala & Kankaanranta 2012). Sana, Weston, and Cepeda (2013) stressed that multitasking has become a growing concern in education, as learners' comprehension may be impaired when they are performing multiple tasks during learning. Also, Beland and Murphy (2015) argued that mobile phones can have a negative impact on learning through distraction and that banning mobile phones can improve outcomes for the low-achieving students. However, Beland and Murhphy (2015) also highlighted that mobile phones can be a useful learning tool if their use is properly structured. Also, Chu (2014) highlighted that, without proper learning design, the performance of students might be disappointing due to the heavy cognitive load. Costabile et al. (2008) argued that there were no significant differences between learning outcomes with two different conditions: paper-based and mobile. However, the different conditions gave rise to different behavioral and social conditions. Also, Hwang et al. (2010) observed that the difference in the learning outcomes resulted from the different teaching methods applied. Thus, the teacher can influence how students decide to direct their attention during class time by creating enriching, informative, and interactive classes and activities that are appropriate for students' skills and needs.

One issue that should also be acknowledged is the novelty effect related to technology usage in an educational context. Novelty effect means that learners and teachers are more likely to use technology because it is new to them than those who have used the technology for a longer period of time (Cheung & Hew 2009, 169). Ng and Nicholas (2013, 705–706) observed that students' statements relating to the effectiveness of a mobile learning program decreased between the start of the program and 12 months later; the students became less excited and thought that the mobile technology did not help them learn better or make learning easier or more interesting.

Earlier studies also indicated that integrating technology meaningfully into instruction tends to move classrooms from teacher-dominated to student-centered environments in which students work cooperatively, have more opportunities to make choices, and play a more active role in their learning process (Pitler, Hubbel & Kuhn 2012, 20). Hence, technology use can transform classroom practices and extend learning in such a way that it has a positive impact on student achievement (Brooks-Young 2010, 5–13).

Basically, there are both advantages and disadvantages to different mobile technologies and no single device is any better than another (Schofield, West & Taylor 2011, 44). Some American schools are now switching their iPad tablets to Chromebook laptops to better meet the established learning goals and needs (Murphy 2014). In other words, it is all about the educational needs. Mobile learning should be aligned with existing educational needs (UNESCO 2011, 11). However, the aim should not be to convert existing materials and courses to fit on a smaller screen. Instead, mobile learning should enable the opportunity to be creative and to leverage the capabilities of the mobile device. (Haag 2012.) Thus, the aim of mobile learning should be to offer new opportunities for learning that extend learning beyond the traditional teacher-led and classroom-bound approaches. Learners with mobile devices can go into the field, interact with other people, and gain concrete knowledge instead of sitting in the classroom and listening to a teacher. Mobile devices provide an opportunity to bridge the gap between formal learning and informal learning because learning is not bounded by a fixed time or location. Mobile devices can also be used in diverse subject areas and learners can construct and apply knowledge and skills either individually or collaboratively in situated contexts. (So, Kim & Looi 2008, 114–115.) Hence, mobile learning should involve more than drill and practice tasks (UNESCO 2011, 17). According to Norris and Soloway (2013, 115), the difference lies in using mobile technology with a new pedagogy and using devices as essential tools, not as supplemental tools for learning. Thus, mobile learning can be one way to transform the educational experience (Stoeger 2013, 480).

However, using technology should not be the goal of a lesson plan; instead, technology should be a tool for making the lesson plan work (Pitler, Hubbell & Kuhn 2012, 221). It is important to first design a quality lesson plan (i.e., identify learning objectives, strategies, and assessment) and then to select the technologies to support that lesson. Stanton and Ophoff (2013) proposed eight steps for designing and implementing mobile learning (FIGURE 7).

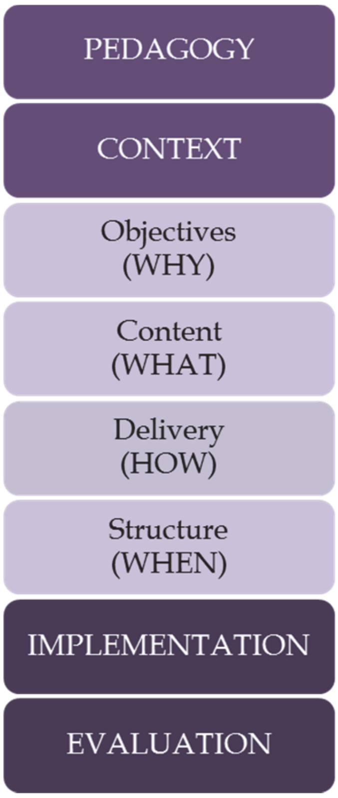

FIGURE 7 Eight steps for designing and implementing mobile learning (adapted from Stanton & Ophoff 2013, 517)

These eight steps highlight pedagogy, context, technology, and feasibility. The pedagogy and context naturally affect the concepts of the course. The actual design process includes the why, what, how, and when blocks (i.e., consideration of the objectives, content, delivery, and structure of the course). The implementation and evaluation ensure that the design meets its objectives (i.e., the mobile learning is feasible). Hence, it is important for mobile learning to exist within pedagogy and within an understanding of the contexts in which learners exist. In the mobile learning planning process, it is particularly important to consider aspects such as technology, context, usability, and pedagogy along with the objectives of the course. (Stanton & Ophoff 2013.)

Milard et al. (2013, 106) argued that the challenge is no longer to find the best ways to deliver knowledge, but rather to design, develop, and implement interactive learning experiences and activities to engage learners and inspire them to learn. It is especially important to perceive mobile learning as part of a learning continuum that includes multiple learning tasks and multidisciplinary learning (Cinque 2013, 222). However, the learning experiences should not be too bewildering or overly complex (Rogers & Price 2009, 16). Mobile learning systems should be user friendly, easy to use, and intuitive to be suitable and attractive to learners (Wang, Wu & Wang 2009, 110). For instance, Rikala and Kankaanranta (2012) highlighted that students' motivation can suffer and they can become frustrated if they encounter problems with technology.

Basically, three dimensions are important in activity design: content, incentive, and interaction (FIGURE 8).

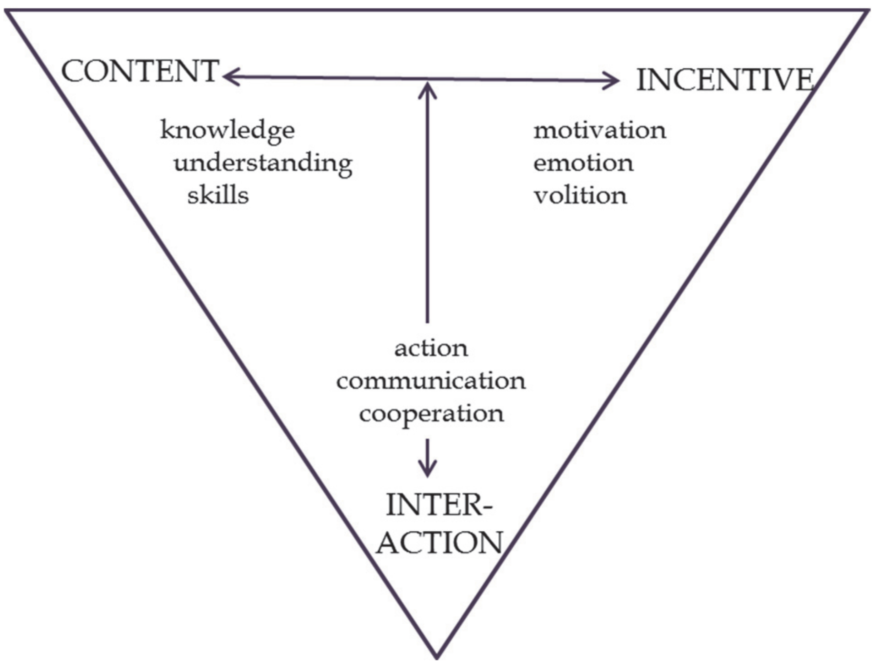

FIGURE 8 Three dimensions of learning (adapted from Illeris 2009, 10)

Ertmer and Newby (1993, 61) highlighted that both learners and tasks should be considered. Thus, the nature of the learning task as well as the proficiency level of the learners must be taken into account. Therefore, content, incentive, and interaction dimensions should be considered when designing mobile learning instruction. The content dimension concerns what is learned (e.g., knowledge, skills, opinions, attitudes, values, ways of behavior, methods, strategies). The incentive dimension provides and directs the internal mental energy that is necessary for the learning process to take place (e.g., feelings, emotions, motivation, volition or free will). (Illeris 2009, 10.) Thus, learning depends greatly on the learner, and therefore the learner's cognitive abilities, memory, prior knowledge, emotions, and motivations play a significant role in the learning process (Koole 2009, 30–31). It is important to acknowledge that individuals learn differently and that people learn what is personally meaningful to them (Brandt 1998, 5–7). The interaction dimension provides the impulses (e.g., perception, transmission, experience, imitation, activity, participation) that initiate the learning process (Illeris 2009, 11). The interaction aspect in learning is important because much learning occurs through social interaction. People also need feedback to learn. (Brandt 1998, 8–9.) The content and incentive dimensions are always initiated by impulses from the interaction processes and integrated in the internal processes of elaboration and acquisition (Illeris 2009, 10).

In a school context, the focus is typically on the learning content. However, the incentive aspect (e.g., how the situations are experienced, what sort of feelings and motivations are involved) is also crucial and should not be forgotten. Both content and incentive depend on the interaction process. In other words, if the interaction in the lesson is not adequate or acceptable, the learning either suffers or something entirely different from what is intended may be learned. (Illeris 2009, 10–12.) Learning is also situated, which means that it takes place in a certain context that is part of the learning and influences both the learning process and its results (Illeris 2007, 214). Learning can occur in a number of contexts and learning spaces, including everyday life, the school and education system, working life, and the electronic-based learning space (Illeris 2007, 232).

3.6 Aspects that Affect Mobile Learning Integration

In a study by Rikala, Vesisenaho, and Mylläri (2013), teachers were ambitious and open to changing their pedagogies with the use of tablet devices; however, all the pedagogical potential and opportunities were not utilized. The low student-device ratio was one reason why the teachers' tablet device use primarily involved technology replacement tasks, such as searching information and giving presentations. The student-device ratio was also seen as an important factor for successful deployment of tablet devices in studies by Grant and Barbour (2013) and Heinrich (2012). Also, Sharples (2013) highlighted that the availability of technology is a key factor influencing the success of mobile learning integration.

It is obvious that the changing landscape of the mobile technologies and the usage patterns create challenges for mobile device utilization for educational purposes (UNESCO 2011, 22). Some people also consider it challenging that mobile devices have a small screen, limited processing power, and reduced input capabilities (Al-Hmouz & Freeman 2010). Park (2011, 83), however, stated that in light of how rapidly mobile devices are improving, the technical limitations may be only a temporary concern. The present mobile technology in general allows characteristics such as ubiquity, personalization, interactivity, and collaboration because of its size, weight, and portability (Stanton & Ophoff 2013, 503).

The unquestionable fact, however, is that mobile devices are not being developed specifically for the educational context. Mobile devices, such as tablet devices, incorporate a range of applications, including games and entertainment. Therefore, many European governments, policy-makers, parents, and teachers treat mobile technologies as disruptive. Some countries have even banned or restricted mobile device use in the school context. (Hýlen 2012, 34.) UNESCO's (2011, 12) Mobile Learning Week Report, for instance, suggested that many teachers have experienced the frustration of students sending text messages on their mobile phones during class. Therefore, it is important to set guidelines for ensuring the appropriate use of mobile devices in an educational context (Sharples 2013).

Another reason for the minimal use of mobile devices in the educational context is that teachers are either not familiar with the specific tools or not able to see the link between the tool and the learning opportunities (Ferrari, Cachia & Punie 2011, 104). Rikala, Vesisenaho, and Mylläri (2013) argued that although the infrastructure and technical support for the appropriation of ICTs currently exist, and many teachers are aware of them, the problem might be that clear guidelines and frameworks are lacking. However, this gap can be bridged, for instance, with examples of classroom practice (i.e., best practices). Hence, teachers should have examples of how to integrate mobile technologies into teaching and learning and with other tools (UNESCO 2011, 16). Such examples can assist a teacher to find appropriate tools and learn how to use them as well as design his or her own implementations. This kind of cyclic process is described, for example, in the technology learning cycle (see FIGURE 9), which aims to advance technology use in an educational context (Howland & Wedman 2004).

The challenge is to design new forms of teaching and learning supported by mobile devices (Sharples 2013). Some teachers, for instance, might be unfamiliar or uncomfortable with the student-centered learning that mobile technologies can facilitate and, therefore reluctant to use mobile devices for educational purposes. Thus, it is important to clarify whether there is a need for content knowledge, pedagogical knowledge, or ICT skills. (UNESCO 2011, 16.) These kinds of knowledge and skills are a solid part of a teacher's competencies.

Such competencies include inter alia teachers' knowledge about the subject matter to be learned or taught, teachers' knowledge about the processes, practices, and methods of teaching (e.g., learning theories), and teachers' knowledge about how to work with technology and how to apply technological tools and resources to teaching and learning. (Koehler & Mishra 2009.)

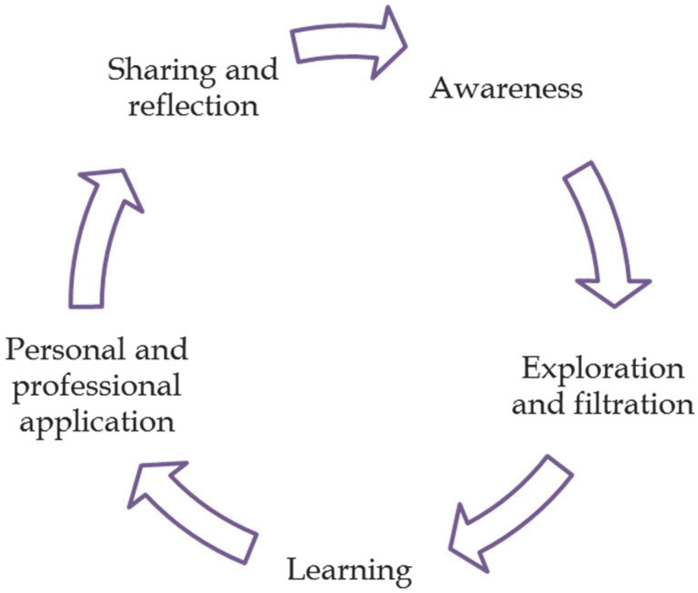

FIGURE 9 Technology learning cycle (adapted from Clark 2012; Howland & Wedman 2004)

Thus, successful technology integration requires an educator's knowledge about learning as well as about how best to integrate technology into the curriculum (Mohammad & Mohammad 2012). Therefore, a teacher's competencies are an essential part of successful technology integration. Hence, it is important to remember that technology doesn't teach; teachers teach (UNESCO 2011, 18).

Overall, the technology integration in teaching is a complex interplay of three primary forms of a teacher's knowledge: content knowledge, technology knowledge, and pedagogical knowledge (Koehler & Mishra 2009). This complex interplay of these three forms of teachers' knowledge is illustrated in the TPACK framework in FIGURE 10. The content, pedagogy, technology, and contexts all have roles to play both individually and together. Therefore, the TPACK framework suggests that teaching successfully with technology is balancing among all components. (Koehler & Mishra 2009.)

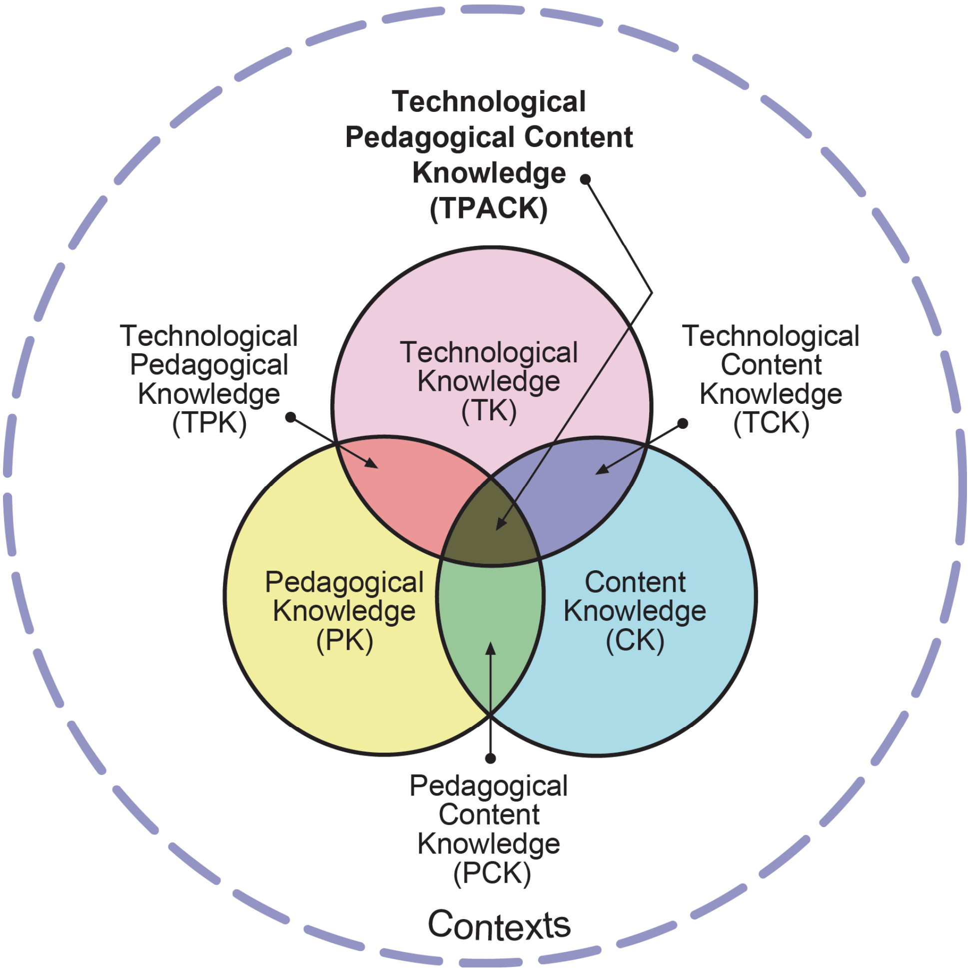

FIGURE 10 TPACK framework (reproduced by permission of the publisher, © 2012 by http://tpack.org)

Tay, Liam, and Lim (2013, 34–35) suggested that two factors, technological infrastructures and teachers' beliefs and practices, are significant factors affecting ICT integration and implementation. According to Tay, Liam, and Lim (2013, 34–35), curriculum, school leadership, and professional development play supporting but less visible functions (FIGURE 11). School leadership, for instance, influences the technological infrastructures and support, curriculum, and professional development. The technological infrastructure, curriculum, and professional development, in turn, influence teachers' beliefs and practices. (Tay, Liam & Lim 2013, 34–35.)

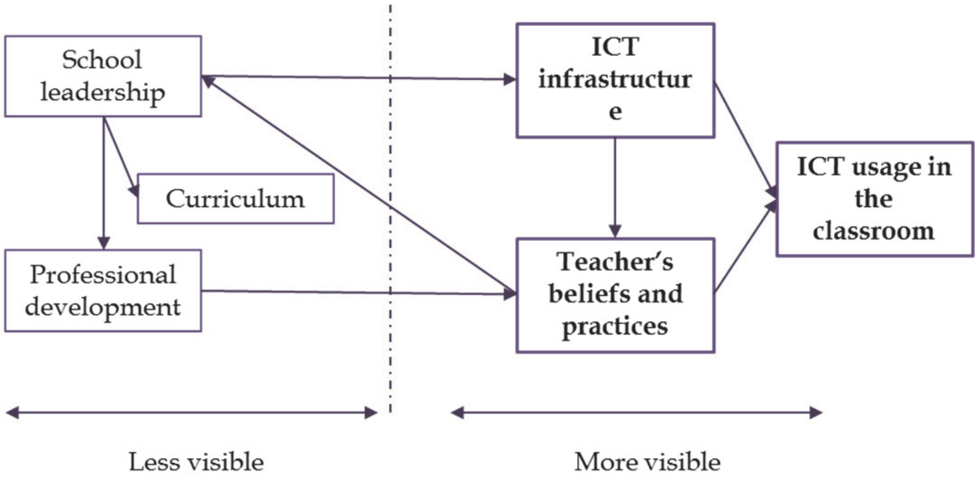

FIGURE 11 Factors affecting ICT integration (adapted from Tay, Liam & Lim 2013, 34)

Cochrane (2010, 146) stated that one key factor for mobile learning integration and sustainability is the development of an institutional cultural and strategy shift that supports and facilitates a teacher's pedagogical shift. Also, Sharples (2013) emphasized the importance of institutional support. Capretz and Alrasheedi (2013, 266) highlighted that a lack of factors such as technical competence of educators, development of assessment techniques, and institutional support may explain the slow adoption of mobile technologies in the educational sector. According to UNESCO (2011, 10), an essential condition for mobile learning is its need to be systemic, including issues such as affordability, leadership, a shared vision for implementation, teacher training, partnerships, and related policies. Lam, Kowk, and Wong (2011, 761) argued that teachers should be provided with training and continuous support. Thus, sufficient support and especially teachers' open minds are crucial in implementing new ideas and approaches in an educational context (UNESCO 2011, 11). Lefoe et al. (2009, 16), for instance, highlighted that it is no surprise that new technologies have not had a large impact on pedagogy because teachers generally find it challenging to engage in new ways of thinking about their teaching within current workload structures. Ertmer (1999, 48) stated that the barriers of ICT integration can be divided into first-order barriers, which include issues such as lack of adequate access, time, training, and support, and second-order barriers, which include the teacher's pedagogical and technological beliefs and willingness to change. Thus, one clear barrier for mobile learning is negative teacher perceptions and beliefs about mobile learning (UNESCO 2011, 12). Lefoe et al. (2009, 16) have stated that teachers who change their teaching practices through new technologies are often enthusiastic individuals working with their own projects.

Ally and Prieto-Blázquez (2014, 145) stressed that teacher training must be re-invented because the current model relies on classroom-based face-to-face delivery and does not prepare teachers for the technology-enhanced educational system. Hence, teachers must be trained in their new roles as mobile learning facilitators. Therefore, teachers need to have basic knowledge of the technology and its features as well as how to design effective learning strategies for mobile learning where learning is learner-centered rather than teacher-centered (Ally 2013, 6). In particular, it is important to provide hands-on learning experiences and help teachers develop their technological, pedagogical, and content skills (An & Reigehult 2012, 61). For these reasons, it is critical to provide professional development, resources, and sufficient support for teachers to afford equal opportunities to develop their teaching practices.

3.7 Summary of Mobile Learning

The literature (Chapter 3; see also Rikala 2013) has indicated that the concept of mobile learning is still challenging as a commonly acknowledged definition and cohesive theory are missing. However, at the same time, the literature has also suggested that mobile technologies can enhance and extend teaching and learning. Thus, mobile learning can be seen as a method of transforming the educational experience. Mobile learning is clearly the next milestone of educational technology and therefore it is important to understand mobile learning and the factors that affect mobile learning integration in an educational context. Based on the literature (Chapter 3), it is also important to build a theoretical basis for mobile learning. Mobile learning has unique possibilities. However, traditional approaches and theories may fail to take them into account. Therefore, this study aims to explain aspects of mobile learning and their interrelationships as well as develop a mobile learning framework.

There are various ways and diverse subject areas in which mobile devices can be utilized in an educational context. Multi-functional applications apply to a variety of uses, but applications are also customized for certain purposes, like bird-watching. (subchapters 3.3 and 3.4.) However, no mobile learning activity exists ready-made in a piece of technology or software. Hence, mobile devices or applications by themselves do not guarantee their potential or use and the simple adoption of mobile devices does not guarantee mobile learning (Grant & Barbour 2013, 291). The literature (subchapter 3.5) has also stressed that mobile learning clearly requires preparation and design. The teacher structures the learning activity and establishes its aims and objectives: What kind of added value and opportunities do mobile technologies provide? What kind of applications and devices are suitable for the purpose? Learning theories, pedagogies, and educational requirements must be the basis of mobile learning design (Ge et al. 2013, 343). Thus, mobile technology should not be used only for its own sake. It is not worthwhile to reproduce old pedagogies with mobile technologies. Hence, the technology and pedagogy must go hand in hand. Basically, mobile learning requires rethinking strategies (Haag 2012). Meaningful mobile learning is not an isolated activity or phenomenon. It should be integrated as part of the learning continuum and strategies which include multiple tasks and multidisciplinary learning. The mobile learning design should take into account a learner's needs and preferences, technology, context, usability, and pedagogy along with the objectives of the course. (subchapter 3.5.)

The literature (Chapter 3) has highlighted that mobile learning is not merely learning by using a mobile device or application. It should support new ways of working and interacting in a different context inside and outside the classroom. The mobile learning experience should be interactive, flexible, personalized, and spontaneous. Learners with a mobile device can go to the field, interact with other people, and participate in physical environments to gain knowledge, instead of sitting in a classroom (So, Kim & Looi 2008, 114–115). Thus, mobile technologies offer various opportunities to extend teaching and learning beyond the traditional teacher-led teaching. Mobile technologies can enhance a learning process by providing access to content in multiple formats and by highlighting the contexts and uses of the information (Koole 2009, 31). Thus, learning materials are not limited to textbooks. The instruction and actions can be differentiated to accommodate different learning needs and styles. Mobile devices can also be used to co-construct knowledge, to solve problems, and to fill information gaps (Kukulska-Hulme & Shield 2008, 283). Hence, mobile technologies can support innovative teaching practices such as student-centered pedagogies, extending learning beyond the classroom, and integrating ICT into teaching and learning which, in turn, can support learners' development of the skills they will need in future life and work (subchapter 3.4). Overall, the literature (Chapter 3) has indicated that well-planned and structured mobile learning activity, where issues relating the technology, context, usability, and pedagogy are presented along with the objectives of the course, can be highly motivating and attractive for learners.

Based on the literature (subchapter 3.6), mobile learning also requires adequate ICT infrastructure, including tools, equipment, and networks, as well as sufficient support and competent teachers. The availability of devices and guidelines for appropriate mobile device use in an educational context is a key issue relating to mobile devices and their integration. Mobile learning devices and applications should also be user friendly, intuitive, and attractive for learners. Teachers also need knowledge and skills regarding how to apply technologies to teaching and learning. However, everything begins with an awareness of available technologies and their potential uses. Therefore, sharing examples of how technologies can be utilized in an educational context is important. Hence, neither available devices nor awareness and knowledge guarantee mobile learning. Also, the school culture affects mobile device integration. A shared vision and policies should support the use of mobile devices and the sharing of examples and ideas. Also, possibilities for professional development may promote mobile technology integration. Nevertheless, a great deal depends on the teacher and his or her beliefs and practices. Ng and Nicholas (2012, 698), for instance, argued that teachers are central to the success and sustainability of mobile learning. An and Reigeluth

(2012, 61) emphasized that teachers' beliefs and practices are continually shaped by the values, opinions, and expectations of influential others. Therefore, according to An and Reigeluht (2012, 61), building communities of practice, social networks, or collegial groups where teachers can share and explore new methods and tools is important and may also provide a significant support channel outside the formal training. Thus, teachers should be trained in their new roles as mobile learning facilitators.

The literature (Chapter 3) has highlighted several factors that influence mobile learning in an educational context. Some of these are the same as those related to ICT integration in an educational context; after all, mobile learning is a part of educational technology. The literature has also stressed that mobile learning has some unique aspects. Based on the literature, however, there exists as yet little work which aims to explain the complex interrelationships of mobile learning (subchapter 1.1). Mobile learning has been fragmented and therefore there has not been enough experience and practice to justify theory abstractions (subchapter 3.3). Thus, a solid mobile learning framework can integrate different mobile learning aspects, highlight complex interrelationships, and justify theory abstractions.

4 DESIGN CYCLE ONE: DEVELOPING AN INITIAL MOBILE LEARNING FRAMEWORK BASED ON THE LITERATURE

The literature (Chapter 3) indicates that mobile learning is the next milestone of educational technology. However, the theoretical basis of mobile learning is still fragmented and certain aspects and interrelationships of mobile learning need to be clarified. Therefore, the aim of design cycle one was to develop an initial mobile learning framework and to address the core aspects and characteristics of mobile learning (i.e., answering research question one; see subchapter 1.2). Hence, the aim was to try to find answers from the available literature and to develop an initial solution, as this is typical in the first phase of design-based research (see subchapter 2.3). This initial solution is also the starting block for the further development of the mobile learning framework.

The mobile learning literature has clearly emphasized the need for a solid mobile learning framework (Chapter 3; see also Rikala 2013, 5). Thus, the design-based research process began when it was realized that a solid mobile learning framework is missing and that several researchers have highlighted the need for a cohesive framework. For example, in their study of challenges and opportunities to support learning with mobile devices, Serrano-Santoyo and Organista-Sandoval (2010, 87) clearly stated the need to continue to develop a solid and cohesive theoretical mobile learning framework. Also, Park (2011, 79) stressed that 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. Hence, prospective research can offer something new in the field of mobile learning as well as in teaching and learning practices.

In design cycle one, development took place on the basis of the literature. Therefore, the background of the initial mobile learning framework is based on various mobile learning frameworks. The mobile learning frameworks were searched and selected mainly by using the snowballing technique, which means that the data have been searched by tracking down references in the bibliographies of various articles (Jalali & Wohlin 2012). The data searches were also conducted with keywords such as mobile learning and mobile learning framework[11]. The objective of the information retrieval was to find diverse mobile learning frameworks from the early years of mobile learning (i.e., from 2005) to the present. Because mobile learning has an ascending trend and research in the field of mobile learning has been conducted all over the world, multiple mobile learning frameworks are available. The result of the snowballing technique, however, offered 17 diverse and interesting frameworks, which also provided a good basis for the mobile learning framework design.

The literature indicates that even though the concept of mobile learning is and has been challenging and very diverse theoretical perspectives and approaches have been applied, many researchers have attempted to encapsulate the unique characteristics of mobile learning in the form of a framework (see TABLE 12). The proposed frameworks range from complex multi-level models to simpler and smaller frameworks. All of the frameworks emphasize different characteristics, and their purpose of use and theoretical background vary. Thus, a solid mobile learning framework is still missing. Possibly for this reason, the mobile learning pilots and trials have also been characterized by short-term small-scale studies focusing on either user acceptance or user attitude. This, in turn, may be why mobile learning has not yet been widely integrated into everyday educational practices.

TABLE 12 Some of the existing mobile learning frameworks

Author(s)(Year)	**Core aspects/ characteristics of the framework**	**Theoretical background/pedagogical approach**	**View of mobile learning**	**Purpose of use**
Mostakhdemin-Hosseini, and Tuimala (2005)	Mobile usability, wireless technology, e-learning system	User studies, e-learning	Natural evolution of e-learning	Development tool
Sharples, Taylor, and Vavoula (2005)	Technological layer, semiotic layer	Cultural-historical activity theory	Learning mediated by knowledge and technology	Analysis tool
Motiwalla (2007)	Push and pull mechanisms, personalization, collaboration	Constructive and conversational learning	An extension of e-learning	Development tool

(continues)

[11] The data searches were conducted from the Jyväskylä University library's Nelli portal which provides access to relevant databases, e-journals and other electronic resources, the Google search engine, and Google Scholar.

TABLE 12 (continues)

Author(s) (Year)	Core aspects/ characteristics of the framework	Theoretical background/pedagogical approach	View of mobile learning	Purpose of use
Parsons, Ryu, and Cranshaw (2007)	Generic mobile environment issues, learning contexts, learning experiences, learning objectives	Game metaphor	Portable communication devices as central to m-learning environments, given access to the learning content.	Analysis tool, design tool
Liu, Salomaa, Huang, and Ma (2008)	M-learning activity design, requirement and constraint analysis, m-learning scenario design, m-learning technology environment design, mobile learner support services design	Action research results	To enrich people's learning experiences anytime and anywhere in a most convenient way with their mobile phones.	Design tool
Koole (2009)	Device aspect, learner aspect, social aspect, context of information	Activity theory constructivism	A process resulting from the convergence of mobile technologies, human learning capacities, and social interaction	Guiding tool, development and design tool
Park (2011)	Transactional distance, social nature of an activity	The transactional distance theory	Mobile technologies as a learning tool in the distance learning environment	Analysis tool

(continues)

TABLE 12 (continues)

Author(s) (Year)	Core aspects/ characteristics of the framework	Theoretical background/pedagogical approach	View of mobile learning	Purpose of use
Tan, Zhang, Kinshuk, and McGreal (2011)	Learner, location, time, content, device	Adaptive learning	Mobile learning is considered non-formal learning, but is an organized and structured method of learning external to the formal learning environment; on the other hand, mobile learning is described as learning anytime and anywhere	Development tool
Issa, Al-Bahadili, and Abuhamdeh (2011)	The main system criteria, mobile devices, quality of services, application and learners' requirements constraints	System criteria, just-in-time learning	Learning through relatively small, low-weight device to accompany users anytime and anywhere	Analysis tool, development tool
Ozdamli (2012)	Integration of tools, pedagogical approaches, assessment techniques, teacher training	Constructivism, blended learning, collaborative learning and active learning	Applying mobile technology to learning	Guiding tool
Kearney, Schuck, Burden, and Aubusson (2012)	Authenticity, collaboration personalization, unique time-space contexts of mobile learning	Socio-cultural perspective	Process of learning mediated by a mobile device	Analysis tool, design tool

(continues)

TABLE 12 (continues)

Author(s) (Year)	Core aspects/ characteristics of the framework	Theoretical background/pedagogical approach	View of mobile learning	Purpose of use
Sha, Looi, Chen, and Zhang (2012)	Self-regulation as agency, mobile devices as social, cognitive, metacognitive tools, learning process as exercises of agency, social and pedagogical support for learner autonomy	Self-regulated learning	To learn anywhere and anytime; entails learners being motivated and able to self-regulate their learning	Analysis tool
Wei and So (2012)	External level (social, cultural, and technical factors) inter-medium level (content, context and device) internal level (learner attitude and experiences)	Situated learning and contextual learning	Mobile learning is not about only the mobility of the learners and devices but also the mobility of learning across contexts	Evaluation tool
Ng and Nicholas (2013)	Relationships between technical aspects and people-related factors	Cisler's framework for sustainability of information and communication technology (ICT) in education	Transcend teacher-defined knowledge or approaches by accessing multiple, alternative sources of information	Guiding tool

(continues)

TABLE 12 (continues)

Author(s) (Year)	Core aspects/ characteristics of the framework	Theoretical background/pedagogical approach	View of mobile learning	Purpose of use
Prasertsilp (2013)	Impacting factors, mobile learning environment, learning outcomes	Social constructivist theory, activity theory	Mobile learning is mode for teaching and learning to deliver content to learners; mobile learning can aid both formal learning in traditional classrooms and informal learning outside classes	Design tool
Bensassi and Laroussi (2014)	Mobile learning activity, context, content, technical support, learning process	Dependability evaluation	Mobile learning supplies a learner with electronic information and content that aids in the acquisition of knowledge regardless location and time	Evaluation tool
Scanlon et al. (2014)	Key elements are places, tasks, tools, social support, time, and learning journey	Incidental learning	Mobile devices with their portability provide the flexibility to learn wherever and whenever; however, the provision of learning support also needs to take into account the context	Analysis tool

All of the proposed mobile learning frameworks and models emphasize different characteristics (TABLE 12). Some are clearly technology centric, some highlight pedagogy, and some view mobile learning in a more holistic way. However, aspects such as learner, device, context, time, content, social interactions, usability, pedagogy, and surrounding culture are shared (see TABLE 12). Also, Crompton (2013a, 3–4) argued that aspects such as **context, learner, device, social interactions,** and **pedagogical approaches** are the central constructs of mobile learning.

First, mobile technology can transcend spatial and temporal restrictions (Chapter 3). In other words, it can support learning anywhere and anytime. Learning can occur in **different contexts** inside and outside the classroom and the learning situations can be either formal planned lessons or informal unplanned and spontaneous learning experiences. Second, the learning experiences are **motivating for learners** as learners can work at their own pace and in the ways they prefer (Chapter 3). Learning situations are personalized and consequently also interesting and meaningful to learners. Third, mobile devices are easy to use, intuitive, and portable and enable learners to concentrate on the task in a specific context, not the device itself. A **mobile device** enables learning on the move and in different contexts (Chapter 3). Fourth, learners can exchange information and acquire knowledge with **rich connections to other people and resources** mediated by a mobile device (Chapter 3). Different kinds of interactions can stimulate learning. For this reason, the relationships and interaction with other learners, experts, systems, and contents should be especially considered. Finally, **pedagogical practices'** influence on the mobile learning activity as well as the environment must also be taken into account. The teacher plans the situations in which the mobile technology is used, the learning goals and contents, and how learners are going to use mobile technology to achieve the learning goals (subchapter 3.5). Decisions about the learning environment, for instance, can affect the spontaneity and formality of the learning experience.

4.1 Designing the Initial Mobile Learning Framework

Based on the findings of the literature (Chapters 3 and 4), an initial mobile learning framework was constructed. In particular, the aspects identified by Koole (2009) and Kearney et al. (2012) in their respective frameworks provided a good basis for construction of the initial mobile learning framework. Both of their frameworks suggest that mobile learning has certain elementary characteristics that separate it from other types of learning. They both also combined many characteristics that are common to other frameworks and viewed mobile learning holistically.

Koole (2009, 25) described mobile learning as a process resulting from the convergence of mobile technologies, human learning capacities, and social interaction. She introduced the Framework for the Rational Analysis of Mobile

Education (FRAME) model (FIGURE 12), which takes into consideration both the technical characteristics of mobile devices and social and personal aspects of learning. The aim of the FRAME model is to guide the development of mobile devices, mobile learning materials, and the design of the mobile learning teaching and learning strategies.

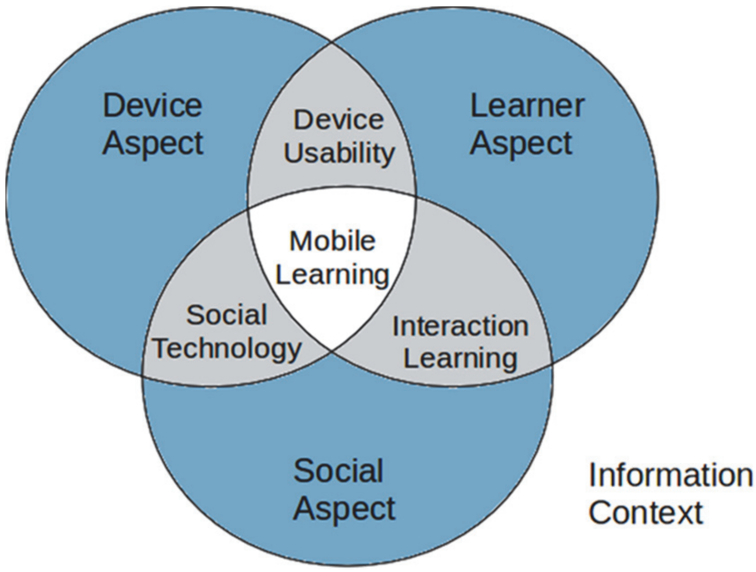

FIGURE 12 FRAME model (adapted from Koole 2009)

In the FRAME model, mobile learning experiences are comprehended as existing within a context of information. Learners can move within different physical and virtual locations and participate and interact with other people, information, or systems. In other words, three aspects, the device, the learner, and the social aspects, intersect. The **device aspect** refers to the physical, technical and functional characteristics of mobile devices, such as input and output capabilities, storage capabilities, and processor speed. These characteristics can have a significant impact on the physical and psychological comfort levels of users because the device provides an interface between the learner and the learning task. Device characteristics, therefore, have a significant impact on usability. A learner equipped with a well-designed device and software can focus on learning tasks rather the device. The **learner aspect** takes into account an individual's cognitive abilities, memory, prior knowledge, emotions, and possible motivations. Koole (2009) highlighted that these aspects may have a particularly significant impact on the information retrieval processes by providing access to content in multiple formats and by highlighting the contexts and uses of the information. The **social aspect** includes the processes of social interaction and co-operation, processes such as information exchange, knowledge acquisition, and sustaining of cultural practices. Koole (2009) emphasized that the intersections where the three aspects overlap contain characteristics that belong to both aspects (FIGURE 12). The device usability intersection contains elements that belong to both the device and the learner, including characteristics that can affect the user's sense of psychological comfort and satisfaction. The social technology intersection, in turn, describes how mobile devices enable communication and collaboration among individuals and systems. The interaction learning intersection considers the impact of interactions on human learning.

Kearney et al. (2012) explored mobile learning from a pedagogical perspective and introduced a framework which highlights three central features of mobile learning: authenticity, collaboration, and personalization. These features are also embedded in the unique time-space contexts of mobile learning (FIGURE 13).

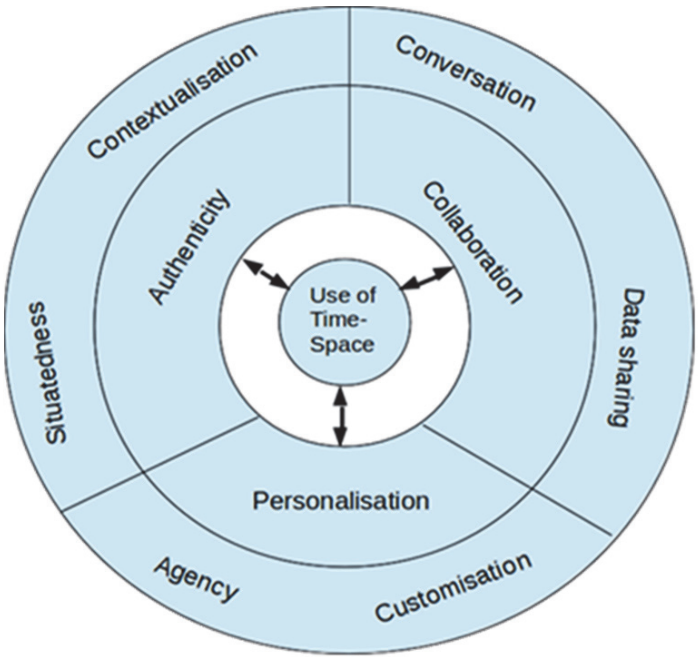

FIGURE 13 Characteristics of mobile learning (adapted from Kearney et al. 2012)

The framework specifies the critical attributes of mobile learning; it also facilitates and supports the design of mobile learning activity. The very basis of the framework is **time-space**. According to Kearney et al. (2012), the organization of time-space profoundly affects mobile learning experiences. The time-space feature also has a symbiotic relationship with the central features of mobile learning (i.e., personalization, authenticity, and collaboration). Each of the central features also has two sub-scales which are closely connected. The **personalization feature**, for instance, has implications for ownership, agency, and autonomous learning. This means that learners have control over the place, pace, and time when they learn and can enjoy autonomy over their learning content. The **authenticity feature**, in turn, highlights the opportunities for contextualized, participatory, and situated learning. Mobile learning activities, for instance, potentially involve high degrees of authenticity as learners participate in rich, contextual tasks involving real-life practices. The **collaboration feature** captures the conversational and connected aspects of mobile learning. In mobile learning activities, learners can enjoy a high degree of collaboration by making rich connections to other people and resources mediated by a mobile device.

Thus, similar aspects like the **learner aspect** and **social aspect** can be found in both frameworks (FIGURE 14). The learner aspect in Kearney et al.'s (2012) framework stems from personalization. A personalization feature includes issues like learner choice, agency, self-regulation, and customization. Thus, the personalization feature involves a learner and factors associated with him or her, similar to Koole's (2009) learner aspect. Therefore, it would be simpler to call this aspect the learner aspect. The social aspect, in Kearney et al.'s (2012) framework, is called collaboration and basically includes the same processes of social interaction and co-operation as Koole's (2009) social aspect; therefore, it is convenient to call this aspect the social aspect.

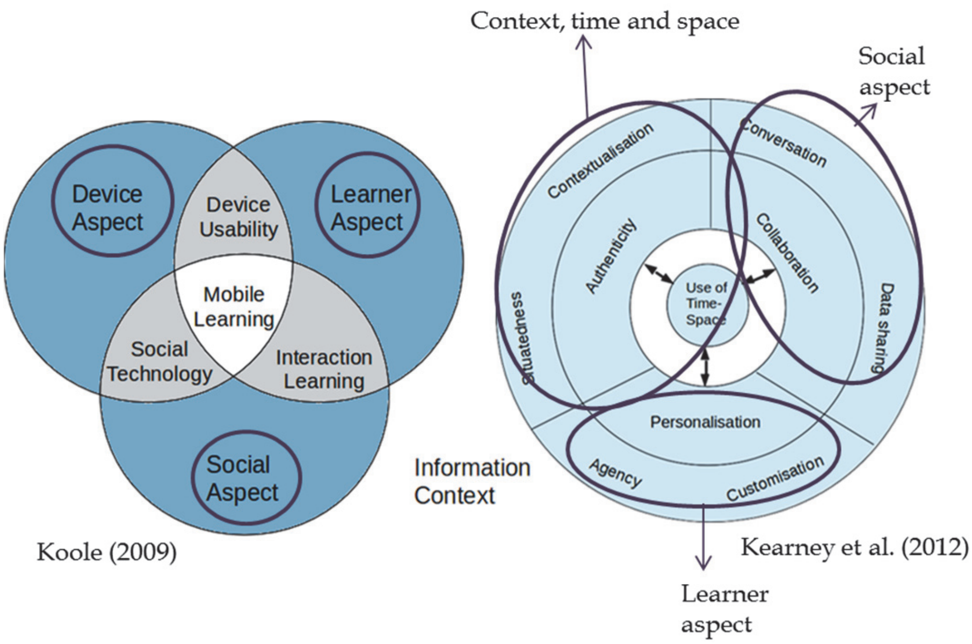

FIGURE 14 Similarities and differences between Koole's (2009) and Kearney et al.'s (2012) frameworks

Kearney et al. (2012) emphasized **context**, **time**, and **space**. In particular, time and space are seen as the central aspects. Context is especially highlighted in the authenticity aspects, where learning is extended in the real world and community. Also, Koole (2009) highlighted the context in her framework. In the FRAME model, mobile learning experiences are viewed as existing within a context of information. The literature (Chapter 3) indicates that mobile technologies have a unique ability to support learning anywhere and anytime and to expand the learning environment to authentic contexts such as parks, museums, and nature. Hence, based on this discovery, the context, time, and space are the central aspects of mobile learning.

Although the **device** aspect is not directly present in Kearney et al.'s (2012) framework, the mobile device enables a variety of spaces, individually tailored activities, and rich connections to other people and resources. Also, the literature (Chapter 3) has emphasized that the mobile device is what enables learning on the move. Therefore, a device aspect is an aspect that should be acknowledged.

Hence, an initial version of the mobile learning framework (FIGURE 15) was developed primarily based on these above mentioned aspects. The framework includes/consists of two levels: the core level and the medium level. This classification is based on the classification of Wei and So (2012), who proposed a three-level framework consisting of the external level (i.e., social, cultural, and technical factors), the inter-medium level (i.e., content, context, and device), and the internal level (i.e., learner's attitude and experience). However, this classification is adapted so that it also aligns with Koole's (2009) FRAME model and Kearney et al.'s (2012) framework. Traxler (2005a) identified the core characteristics of mobile learning. Therefore, the internal level in the initial framework is called the core level. The inter-medium level, in turn, is simply called the medium level.

In the initial mobile learning framework, aspects such as context, time, and space form the core level of mobile learning because authentic contexts, real-life problems, and spontaneous learning are intrinsic features of mobile learning (Chapter 3) and therefore also form the core of mobile learning. In the proposed framework, the mobile learning context also includes constructs that can either support or challenge mobile learning integration, such as ICT infrastructure, teachers' competencies and beliefs, and the school culture.

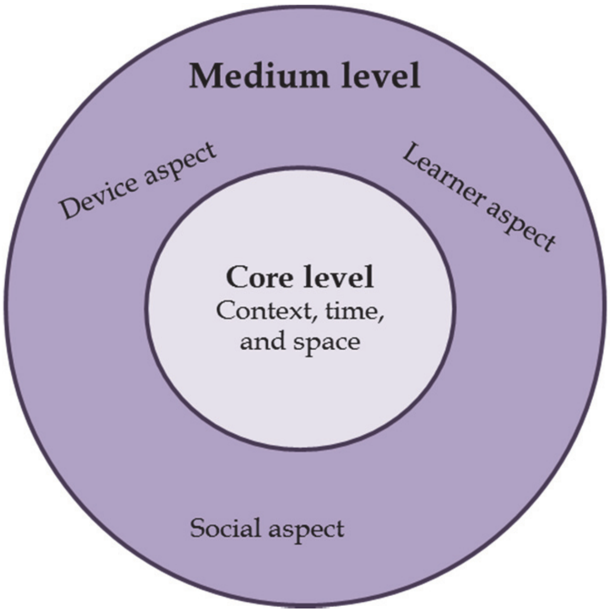

FIGURE 15 Proposed initial mobile learning framework

The medium level consists of other important aspects of the mobile learning process: the learner aspect, device aspect, and social aspect. The learner aspect refers to factors associated with an individual learner that play a significant role in the learning process. In the device aspect, the physical, technical, and functional characteristics of a mobile device are emphasized as they are important factors of device usability, which in turn influences the learner's experiences. The social aspect is associated with the processes of social interaction and co-operation. The literature (Chapter 3), for instance, highlights that the impact of interaction on learning cannot be underestimated.

The earlier mobile learning frameworks (TABLE 12, 81) also highlight various aspects and characteristics such as content, usability, assessment, teacher, and wider socio-technical unity. However, aspects and characteristics such as content, assessment, teacher, and wider socio-technical unity can also be associated with core-level aspects. The device aspect, in turn, can be accompanied with a usability feature.

4.2 Further Development Needs Based on Design Cycle One

The objective of design cycle one was to develop an initial mobile learning framework which also was the starting block for development of the mobile learning framework. The aim was also to identify the core aspects and characteristics of mobile learning. The initial mobile learning framework was developed based on the literature. It consists of two levels. The learner aspect, device aspect, and social aspect form the medium level of the initial mobile learning framework and context, time, and space form its core level (see FIGURE 15, 91).

After design cycle one, many questions remained. First, are the aspects that the literature highlighted (i.e., context, time, space, learner, device, and social interactions) the central aspects of mobile learning (i.e., research question one; see subchapter 1.2)? Or are there also other possible aspects and factors that affect mobile learning in the formal educational context (i.e., research question three; see subchapter 1.2)? For instance, should wider socio-technical unity be taken into account? In the initial mobile learning framework, socio-technical unity is included in the core-level aspects. What about the role of the teacher and pedagogy? Should the learning environment and its constructs be included in the framework? Moreover, how would the different aspects interrelate with each other (i.e., research question two; see subchapter 1.2)? The initial version of the framework only includes broad ideas regarding how the different aspects might interrelate.

Thus, it was clear that the framework still required further development and especially development that would extend the design work to authentic real-world educational contexts to study mobile learning with ordinary teachers and students. Therefore, design cycle two was justified.

5 DESIGN CYCLE TWO: REVISING THE INITIAL MOBILE LEARNING FRAMEWORK BASED ON CASE STUDIES

Design cycle one left many unanswered questions, which called for another design cycle to extend the design work to authentic real-world educational contexts. In design-based research, the researcher and participants usually cooperatively construct interventions and artifacts (see Chapter 2) and therefore it was important to extend the design work to authentic contexts. The objective of design cycle two was to evaluate and further develop the initial mobile learning framework developed in design cycle one based on the literature (see FIGURE 15, 91). The aim was also to address how the different aspects and characteristics would interrelate. Thus, the aim was to find answers to research questions one and two (see subchapter 1.2). The objective of design cycle two was also to examine how teachers integrate mobile applications as a part of their teaching practices. In other words, it intended to study the phenomena of mobile learning with ordinary teachers and students. For this reason, the researcher's role was also minimized in the activity planning process. The researcher's role was to organize the case studies, to assist in the activity design process if needed, provide technical support, observe the implementations, and gather data.

To evaluate and advance the developed initial mobile learning framework as well as to identify interrelationships, four nearly simultaneous case studies (Math Trail, Literature Tree, Nature Tour, and Leaf Structure) were conducted in the context of Finnish pre-school and basic education in the fall of 2012 in Central Finland. The aim of the case studies was to explore how the defined core-level aspects and medium-level aspects emerge in case studies and, especially, to discover how different aspects interrelate. Based on these observations, the framework would be revised if needed. The observations and discoveries made in case studies have also been reflected in scientific articles (see Rikala & Kankaanranta 2014a; Rikala & Kankaanranta 2014b; Rikala 2014a; Rikala 2014b; Rikala 2014c; Rikala, Hiltunen & Vesisenaho 2014). Because the case studies were nearly simultaneous, the analysis and further development of the framework was not done until all of the case studies had been carried out. The case studies were nearly simultaneous due to the intensive schedule of the project in which the case studies were carried out. Hence, the framework was not revised or developed further directly after each case study. However, some slight changes had already been made during the case studies. For example, interview questions were added and revised during the implementation process. This decision, however, does not mix with the traditions of design-based research, and therefore this is an apparent weakness of the study. Thus, within the framework of design-based research, the implementation of the case studies and the revision of the framework could have been conducted in another way. However, the reader should bear in mind that the objective of the study was to design a generic mobile learning framework; not to design or develop mobile learning applications or interventions. Therefore, it was important to get as much as possible data about different mobile learning activities in naturalistic settings.

FIGURE 16 illustrates the analysis and evaluation cycles of design cycle two.

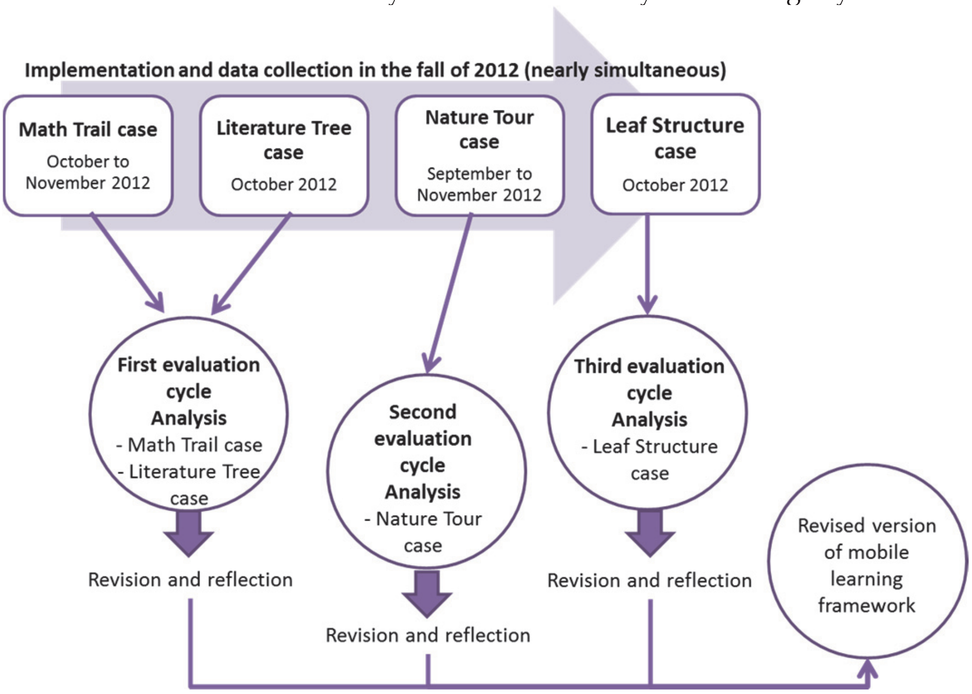

FIGURE 16 Analysis and evaluation cycles of design cycle two

Data were analyzed after all the case studies had been carried out. The data analysis, evaluation, and necessary revisions were done in cycles. The first evaluation cycle included two case studies (Math Trail and Literature Tree). The second included one case (Nature Tour), and the third included one case (Leaf Structure). In the final reflection phase, the observations made in all the case studies were compared to obtain an overall picture, to discover revision requirements, and to construct a revised version of the mobile learning framework. Hence, the design cycle two in its entirety comprises three evaluation cycles.

The following subchapters will describe design cycle two and its evaluation cycles in more detail. First, the design process of the case studies is described (subchapter 5.1) after which the iterative cycles of evaluation and revision are introduced (subchapter 5.2). These iterative cycles of evaluation and revision highlight how the different aspects emerged in the case studies, what development needs arose during the evaluation phase, and how the framework was revised. Finally, the chapter concludes with reflection and an outline of further development needs (subchapters 5.3 and 5.4).

5.1 Designing Case Studies

The use of a case study method in design cycle two was considered appropriate because case studies can provide an in-depth understanding of perspectives, opinions, and expectations (McLeod 2008) and thereby may also highlight important aspects and factors of mobile learning. The four case studies conducted in design cycle two were part of the Personal Mobile Space[12] project. The aim of this project was to build a concept of a mobile service space that can be personalized according to an individual's interests and needs regarding learning and well-being. During the project (2009–2012), several mobile learning concepts and applications were developed and piloted [13] (see Kankaanranta, Neittaanmäki & Nousiainen 2013). During the fall of 2012, twelve case studies were conducted where the aim was to collect data for the Personal Mobile Space project about the user experience as well as aspects that should be considered in further development of mobile applications. The collected data in the twelve case studies primarily focused on the added value, teachers' perspectives, and application suitability for different types of users, situations, and contexts.

For the purpose of the present study, four of these case studies (Math Trail, Literature Tree, Nature Tour, and Leaf Structure) were selected for more detailed examination. These four case studies were chosen primarily because the researcher was responsible for organizing them and therefore had an overall understanding of them. TABLE 13 provides an overview of the four case studies. Each case was unique in terms of school, students, teacher, duration, application, and objectives. The hypothesis was that each of the four case

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12 The Personal Mobile Space project was funded by Tekes (the Finnish Funding Agency for Technology and Innovation) and led by Professors Pekka Neittaanmäki and Marja Kankaanranta from the University of Jyväskylä, Finland.

13 Citynomadi learning trails, Quick Response (QR) code learning tasks, Nature Tour mobile learning application, Digital Counselor eOpo, Local History game trail, Ähtäri Zoo mobile learning application, and Writing Skills mobile application.

studies would highlight specific aspects and factors relating to mobile device integration and that the case studies would also provide an understanding of mobile learning in the Finnish educational context.

Because the aim of the present study was to develop a mobile learning framework, the scope of the study did not involve further development of mobile applications or activities. Thus, one restriction was to focus on user experiences and perspectives as well as how mobile learning appears in a formal education context. This data would highlight the aspects that should be taken into account in the design of a mobile learning framework.

The following subchapters provide a more detailed description of the case study design. The subchapters discuss the selected participants, selected mobile applications, data collection and analysis methods, and the mobile learning activity design.

TABLE 13 Four case studies in design cycle two

Case	School	Teachers	Sample & grade level	Application & objective	Equipment	Duration
Math Trail	Primary school	Teacher 3	24 5th grade pupils (aged 10-11 years)	QR codes mathematics	Loaned smartphones	Short term (two weeks)
Literature Tree	Secondary school	Teacher 5 Teacher 6 Teacher 7	16 9th grade (aged 14-15 years)	QR codes Finnish literary history	Loaned smartphones	Short term (2 x 45 minutes)
Nature Tour	Early childhood education	Teacher 1 Teacher 2 Assistant	29 children (6-year-olds)	A prototype of Nature Tour application nature education	Loaned smartphones	Longer term (two months)
Leaf Structure	Primary school	Teacher 4	19 2nd grade pupils (aged 7-8 years)	A prototype of Nature Tour application nature education	Loaned smartphones	Short term (half a day)

5.1.1 Participants

The interested and volunteer teachers cooperated in developing ways to embed mobile technologies for learning (see TABLE 14). The teachers were reached through inquiries at schools in Central Finland. A short message was sent to the schools in which teachers were asked to participate as volunteers. If a teacher enrolled as a volunteer, a preliminary visit to the organization and consultation with the teacher was completed.

TABLE 14 Participating teachers in design cycle two

ID	Application	School/ case	Gender	Teaching experience	Previous mobile learning experiences
Teacher 1	Nature Tour	Early childhood education/ Nature Tour	Female	Less than 10 years teaching experience	No previous mobile learning experiences
Teacher 2	Nature Tour	Early childhood education/ Nature Tour	Female	More than 20 years teaching experience	Short one-day experience; the previous experience was very positive and raised her interest to try again
Teacher 3	QR codes	Primary school/ Math Trail	Female	More than 20 years teaching experience , 10 of which were in primary school	No previous mobile learning experience
Teacher 4	Nature Tour	Primary school/ Leaf Structure	Male	At the beginning of his teaching career (teacher trainee)	No previous mobile learning experience
Teacher 5	QR codes	Secondary school/ Literature Tree	Female	More than 10 years as a teacher	Short one-day experience
Teacher 6	QR codes	Secondary school/ Literature Tree	Female	At the beginning of her teacher studies (teacher trainee)	No previous mobile learning experience
Teacher 7	QR codes	Secondary school/ Literature Tree	Female	At the beginning of her teacher studies (teacher trainee)	No previous mobile learning experience

During the visits, the mobile applications[14] were presented and preliminary schedules were arranged. Also, two workshops were organized in August 2012 in which the teachers had an opportunity to explore the mobile applications and then enroll as a volunteer. Thus, the participating teachers selected mobile learning concepts and applications that were developed as a part of the Personal Mobile Space project.

The volunteer teachers (TABLE 14) had little or no experience with mobile learning, but all of them were enthusiastic to see how they could use mobile technologies as a part of their teaching practices. Some of the teachers (TABLE 14) had already taught for more than 20 years, and others were at the beginning of their teaching studies or teaching career; in other words, they were trainee teachers. Teacher 2 and Teacher 5 had participated in the spring of 2012 in short pilots and, therefore, they already had a little experience with the selected mobile learning applications.

Thus, in the Math Trail case, 24 5th grade pupils (aged 10-11 years) and their teacher (Teacher 3) participated for two weeks. In the Literature Tree case, the participants included one 9th grade classroom. One teacher (Teacher 5), two teacher trainees (Teachers 6 and 7) and 16 students (7 girls and 9 boys) aged 14-15 years participated in a short-term implementation. In the Nature Tour case, 29 children (6-year-olds), 2 teachers (Teachers 1 and 2), and one assistant participated for two months. In the Leaf Structure case, 19 2nd grade students (aged 7-8 years) and their teacher (Teacher 4) participated in a half-day experiment.

5.1.2 Mobile Applications

As noted earlier, the teachers selected mobile learning concepts and applications that were developed as a part of the Personal Mobile Space project. The teachers had an opportunity to choose an application that would best suit their needs and school curriculum. A brochure of the different applications was produced during the Personal Mobile Space project. The brochure was accessible to all interested teachers on request. If the teacher enrolled as a volunteer, a brief orientation session was also organized. This subchapter will describe the applications that were selected for the four case studies. Two case studies (Math Trail and Literature Tree) utilized Quick Response (QR) codes and two (Nature Tour and Leaf structure) used the Nature Tour mobile learning application.

QR codes

A QR code is a two-dimensional barcode consisting of modules. These square pattern codes contain information such as text, URL links, and other data that can direct users to resources for more information about a particular

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14 Citynomadi learning trails, Quick Response (QR) code learning tasks, Nature Tour mobile learning application, Digital Counselor eOpo, Local History game trail, Ähtäri Zoo mobile learning application, and Writing Skills mobile application.

place or subject (Lee, Lee & Kwon 2011). Users with a mobile device equipped with a QR code reader application and a data connection can scan QR codes to display text, open a web page, send automatic text messages, and perform similar tasks (Rikala & Kankaanranta 2012).

QR codes were developed by a Japanese company, Denso Wave, in 1994 (Law & So 2010). They were originally used to track automobile parts in factories, but today they have much broader application (Shin, Jung & Shang 2012). The popularity of QR codes is growing and one can now find QR codes almost everywhere, from entertainment to business and industry. QR codes appear in magazines, on posters, in ads, in websites, and in product packaging. See FIGURE 17 for a sample code and how it is scanned with a mobile device.

FIGURE 17 Sample QR code and how it is scanned

There is also a variety of ways to utilize QR codes in an educational context, including trail activities and treasure hunts, outdoor and field activities, paper-based tasks, learner-generated content, and working instruction. In trail activities, students explore their communities and solve problems that relate to what they find. In outdoor activities, students can explore life science subjects and a QR code can provide hints when identifying a species or additional information. In paper-based tasks, QR codes can contain links to multimedia resources (e.g., to listening exercises, video clips). In learner-generated content, learners can produce reports or other materials online and share their work through QR codes. In working instruction, the teacher can give directions and information to students with QR codes regarding how to complete their assignments. (Law & So, 2010; Lee, Lee & Kwon 2011; Rikala & Kankaanranta 2012.) Thus, a teacher can decide and design how QR codes are used as a part of teaching and learning. No ready-made solutions are available. However, some guidelines relating to QR code usage in the educational context can be found on Internet sites where teachers and educators share ideas (see Miller 2011). In the Personal Mobile Space project, the aim was particularly to discover diverse ways that QR codes can be used as a part of teaching practices (see Kankaanranta, Neittaanmäki & Nousiainen 2013).

Nature Tour Mobile Learning System

The Nature Tour mobile learning system (Luontoretki in Finnish) was developed and implemented in the Personal Mobile Space project (see Kankaanranta, Neittaanmäki & Nousiainen 2013). As a whole, the Nature Tour system includes a mobile application and a website which together constitute a learning environment for nature and environmental studies. The primary objective of the system is to enhance children's outdoor learning experiences. Outdoor education is widely recognized as the most feasible method of teaching the phenomena of the natural world (Tan, Liu & Chang 2007). The literature has indicated that experiences and quality of outdoor education can be enhanced with ICT (Osawa et al. 2007). Mobile devices, for instance, can support, guide, and extend the learner's thinking process when immersed in nature (Chen et al. 2008).

The Nature Tour mobile learning system (FIGURE 18) was initially developed considering the early childhood and lower primary education settings.

FIGURE 18 Nature Tour mobile learning system

It was developed especially to aid the identification of the main flora and fauna, as well as help the gathering of observations about plants and other natural phenomena. The mobile application, for instance, includes relevant information (e.g., picture and core information) on common species that supports the identification process in the field. It also enables the user to record observations with photographs or audio recordings and to send these observations to a web page where they can be viewed later on. For instance, a child can try to take a picture of a domestic bird (e.g., the great tit or mallard duck) or try to record it chirping or quaking. Alternatively, the child can record plant observations such as pictures of the main characteristics of the plant (e.g., flowers, stems, branches, leaves) for a digital herbarium. A herbarium collection, for instance, is part of the curriculum and biology teaching in Finnish primary school.

Thus, the primary objective of the mobile application is to enhance children's outdoor learning experiences by facilitating identification of species and documentation of the field trip. Continuity of the learning experience can be promoted with activities before and after the field trip. For example, before the field trip, children can familiarize themselves with plants, animals, or fungi because the mobile application is associated with a web page containing relevant information. After the field trip, the children can review the recorded observations and, for instance, create stories. The web page also enables comparison of species and phenomena observed across the country. For example, one group from southern Finland and another group from northern Finland can record their observations and make comparisons.

The Nature Tour mobile learning application was designed so as to avoid limiting its use to a particular pedagogical model. Instead, teachers can design their own activities to respond to their needs and objectives. The mobile application, however, requires the ability to read and, therefore, it requires adult guidance, especially if the application is used with very young children. Hence, the application is designed to provide concrete experiences in nature with the guidance of an adult inasmuch as it is also important for the educator to describe and explain various situations.

5.1.3 Data Collection and Analysis

The data in case the studies were collected with multiple data collection methods: observations, student surveys, and teacher interviews. The questionnaire and interview questions were designed to cover the core aspects of mobile learning and to measure and understand teachers' and students' perspectives, opinions, and expectations of mobile learning.

The earlier mobile learning studies in general had very diverse aims and theoretical and pedagogical approaches and those have illustrated learning across different educational contexts (e.g., schools, universities, museums, informal learning, professional development, workplace settings), with diverse target groups, including children, adult learners, and professionals. Based on the literature review, the research topics have varied and various research methods and data collection instruments have been utilized. (see Rikala 2013, 14–17.) APPENDIX 14 illustrates the varying research topics, methods, and instruments of 40 mobile learning studies conducted over time.

This information about various research topics, methods, and instruments (APPENDIX 14) as well as the core characteristics identified by Koole (2009) and Kearney et al. (2012) (which were also encapsulated as an initial mobile learning framework) were employed when developing the data collection instruments. However, direct linking to specific research or data collection instruments cannot be provided because it was challenging to find suitable tools relating to the varying field of mobile learning research. Therefore, the data collection instruments for the design cycle were self-built to address the research problem and questions. Nevertheless, because the information about earlier mobile learning research methods and instruments guided the data collection and analysis design, several similarities exist.

TABLE 15 presents the themes of the teacher interviews. Some pre-decided questions were included (see APPENDIXES 7, 9, 10, and 12), but deeper questions were asked if necessary.

TABLE 15 Teacher interview themes

The Interview Themes
1. Background Information
2. Context, Time & Place
3. Device Aspect
4. Learner Aspect
5. Social Aspect
6. Mobile Learning Experiment

TABLE 16, in turn, presents the themes of the student questionnaires. The student questionnaires particularly focused on students' overall learning experience and the ease of use of the mobile application.

TABLE 16 Student questionnaire themes

The Student Questionnaire Themes
1. Background Information
2. Learning Experience
3. Device Aspect

The actual survey questions were tailored according to the cases taking into account the mobile learning application used as well as the age of the students. For instance, the survey scales differed. The questions and scales were easier for younger students and visual aids such as smiley faces were also used if needed. The student questionnaires are found in APPENDIXES 6, 8, and 11. The interview and survey questions were also designed to leave room for unexpected discoveries and tailored according to the situation

The data analysis in design cycle two was carried out through the initial mobile learning framework that was developed (FIGURE 15, 91); in other words, it incorporated the device aspect, learner aspect, and social aspect as well as context, time, and place. Later, the pedagogical aspect was also taken under scrutiny. APPENDIXES 15 and 16 represent the analysis frames in more detail. The observations were separated into themes according to the above mentioned aspects and emerging aspects. Thus, the goal of the data analysis was to provide a description of the phenomenon of mobile learning and to deepen the understanding of the factors that influence mobile learning and how they interrelate. Thus, the goal was to answer research questions one and two (subchapter 1.2).

5.1.4 Mobile Learning Activity Design

Cooperating with the teachers yielded the opportunity to design learning activities using meaningful content that also has relevance for the school curriculum. The teachers designed the mobile learning activities and implementations by themselves. However, the researcher assisted whenever needed and especially with the technical implementation. In all cases, an equal opportunity was offered to take advantage of loaned equipment as well as technical support during the whole experiment. The instructional design of each case is described below.

Math Trail

The Math Trail implementation and its contents were planned together with the 5th grade teacher (Teacher 3; see TABLE 14, 97). She has worked as a teacher in basic education for more than 10 years, but this was her first time to take advantage of mobile devices as part of her teaching practices. It was decided that the QR codes would display math problems for students during the trail, which would be located in school settings. In short, a Math Trail activity is a walk to discover mathematics. The walk can be organized almost anywhere – in a neighborhood, a park, or even a zoo. The idea is that a map guides the learners to places where they can formulate, discuss, and solve mathematical problems. The very earliest Math Trail appeared in England and Australia in the mid-1980s, but as the idea of a Math Trail has spread, people have adapted it to suit their specific needs. The idea of a Math Trail is flexible and can easily be amended to meet the need and inventiveness of the users in many different situations and contexts. (Shoaf, Pollak & Schneider, 2004).

The overall objective of the Math Trail implementation was to enhance the students' mathematical skills and to bring variation to the school day and mathematics learning. The learning subject was decimals and the objective of the experiment was to learn how to use them. The teacher said she did not have any specific pedagogical model that she followed in designing the QR code implementation. Instead, she noted that she especially wanted to inspire students to practice mathematical skills. Mathematics was actually an interesting choice for a learning domain because, according to Hwang and Tsai (2011), the ratio for mathematics in mobile learning research has been relatively low. The Math Trail was planned as a self-directed and individual activity, but cooperation was allowed. Along the Math Trail, the students used paper and a pencil to solve the problems. Thus, the experiment actually blended both the traditional and mobile learning approaches.

The Math Trail was implemented as follows. At the beginning of each math lesson, the teacher taught the theory and the students solved approximately five problems from the textbook. After solving these five textbook problems, the students could follow the Math Trail. The Math Trail was located in the school surroundings (e.g., corridors, classrooms, furniture). During the Math Trail experiment, each student had one loaned smartphone and a map of the trail, including QR code locations (FIGURE 19).

FIGURE 19 Math Trail map

For each QR code location, the students answered one problem by scanning the QR code and submitting their answer using the online form of the mobile device. If the answer was correct, the student received a hint for the following QR code location. For example, if the student was at the starting location and answered the problem correctly, he or she would receive the following type of message: "The 3.3 was correct! The next location is A." Resolving the problem in location A, in turn, directs the student to location U, for example. The route does not follow any logic (i.e., it is randomized) so it cannot be inferred in advance.

Contrary to the original idea of the Math Trail, the problems used were the same ones the students were currently solving at school. The decimal problems had to be relevant to the school curriculum and this is why the problems were the same. Hence, this is why the teacher designed textbook-like decimal problems. The Math Trail included 65 decimal number problems, some of which were easy and some somewhat trickier (FIGURE 20). The idea was that the learners can take control over the pace at which they learn and be fulfilled by their achievements. The aim was to ensure that the learners thought that they were treated as individuals and that they were content and learned at their own preferred pace.

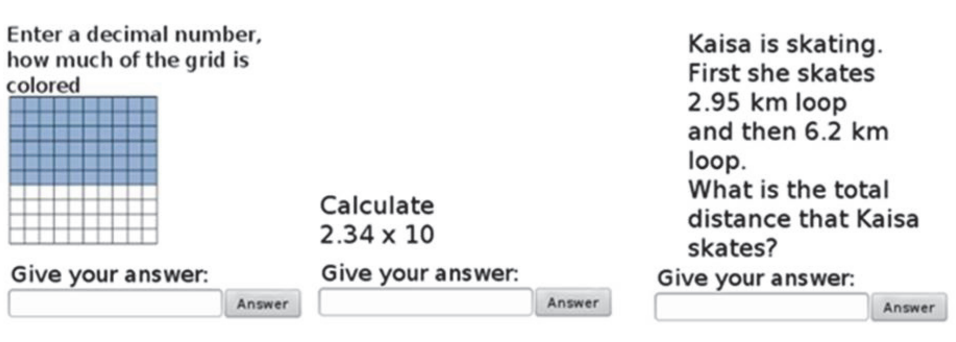


FIGURE 20 Examples of decimal problems

The online forms (implemented with HTML and JavaScript) and the QR codes were prepared by the researcher. Otherwise, the implementation and its contents were designed by the teachers based on the brochure and presentation of possibilities for QR codes provided by the researcher.

Literature Tree

QR codes were also used in the Literature Tree activity, which can be categorized as a trail activity. In trail activity, students explore their surroundings and solve problems that relate to what they find. These kinds of activities can be organized in the form of collaboration or competition between students, but they also can be used to support individual study (Law & So, 2010). Implementation of the Literature Tree activity and its contents were planned together with the teacher and two teacher trainees. All three (Teachers 5, 6, and 7; see TABLE 14, 97) had knowledge about the use of ICT as a part of teaching practices, but they had little or no previous experience with mobile learning.

The overall objective of the Literature Tree activity was to revise the lessons learned earlier about Finnish literary history. The activity contained a Literature Tree map (FIGURE 21) where the students were asked to place certain concepts such as literature styles (e.g., romanticism, realism) in the right places. The activity was located in the school surroundings (e.g., corridors, statues, paintings). The students circulated around the school in small groups and tried to find QR codes which contained hints. Hence, the whole activity was planned to be collaborative. Students worked in small groups (maximum of three per group) and scanned the codes, discussed the concept, and determined its correct place on the Literature Tree map. The hints given by the QR codes were also placed where they could be associated to the environment. For instance, a question relating to the famous Finnish author Aleksis Kivi was next to a statue of the writer (FIGURE 21). The QR codes contained, among other things, blog texts and pictures which helped the students understand the concept and its correct place on the Literature Tree map. The graphics of the Literature Tree map and the storyline were designed by the teacher and teacher trainees, but the technical implementation (e.g., QR codes) was completed by the researcher. Also, a brief orientation session for teachers was organized to give the teachers an opportunity to explore the QR codes and the scanning process.

FIGURE 21 Literature Tree implementation

Nature Tour

The Nature Tour case explored the implementation process of the Nature Tour mobile learning system in the Finnish early childhood education setting. The teachers planned the activities by themselves. The teachers (Teachers 1 and 2; see TABLE 14, 97) had little or no previous mobile learning experience. The teachers were given a brief orientation session about the mobile application as well as written instructions. Based on these instructions the teachers planned the activities.

The application was used in appropriate situations in field trips to arouse children's interest in nature. The objective of the implementation was to begin the children's nature education by having them observe plants, animals, and fungi in an authentic context. A more detailed pedagogical objective was not set. The application also included other categories which allow the wider use of the mobile application in daily life. Therefore, the teachers could also use the application indoors to document the children's play as well as the weather or other interesting daily life conditions.

In the Nature Tour case, the mobile application mainly functioned as a tool for recording observations during field trips. Each child could record his or her own observations. The pictures were sent to the web page and viewed together with the teacher and peers later on. The teachers also assisted the children with the application during the field trips because the application required literacy skills.

Leaf Structure

The Leaf Structure case explored the implementation of the Nature Tour mobile application. However, the setting was the Finnish basic education setting in Central Finland. The teacher designed and implemented the outdoor learning activity himself. A brief session to introduce the main functions of the application and written instructions were provided to the teacher. Based on these instructions, the teacher planned the implementation.

In this case, the learning was extended outside the classroom in the nearby woods. The objective of the outdoor learning activity was to explore and learn local area trees and especially their leaves. The teacher (Teacher 4; see TABLE 14, 97) stated that the aim was to learn at least 10 different species each year. According to the teacher, the species cannot be learned only by looking through a textbook; concrete experiences are also needed. In this case, the students recorded tree leaf pictures, identified species, drew structures and created a memory game. In other words, the students shaped the content for acquiring knowledge about trees and tree leaves. Thus, use of the mobile application was also linked to classroom teaching and learning. Hence, the activity blended traditional teaching and learning.

In this case, the mobile application mainly helped to record observations during the field trip. Each child recorded his or her own observations and worked with his or her own material. After the field trip, the observation pictures were sent to the web page where they were printed. The printed pictures were used to identify the trees with the classmates, the teacher, and other aids like structural pictures of tree leaves (FIGURE 22). The students also drew their own versions of leaf structure pictures based on the printed pictures and constructed a memory game for memorizing the trees and their leaves. Thus, teaching and learning were not bound only to the device or application. Instead, the activity gave the students the opportunity to discover, explore, and reflect on the issue in various ways – in nature by observing and recording concrete tree leaves and in the classroom by processing the collected materials.

FIGURE 22 Structural pictures of tree leaves (source openclipart.org)

5.2 The Iterative Cycles of Evaluation and Revision

As noted earlier, the aim of design cycle two was to evaluate and further develop the initial mobile learning framework constructed in design cycle one (see FIGURE 15, 91). To evaluate and revise the developed framework, data collected in case studies followed the developed mobile learning framework; in other words, it incorporated the device aspect, learner aspect, and social aspect as well as context, time, and place. The aim was to explore how the defined core-level and medium-level aspects emerge in case studies and especially to discover how different aspects interrelate. Based on these findings, the framework would be revised if necessary. The following subchapters cover the iterative cycles of evaluation and revision and highlight how the different aspects emerged in the case studies, what development needs arose during the evaluation phase, and how the framework was revised.

5.2.1 First Evaluation Cycle

This subchapter will describe the first cycle of the evaluation (see FIGURE 16, 94), which included two case studies, Math Trail and Literature Tree. The Math Trail case explored an implementation of QR codes in a 5th grade classroom in Central Finland in October 2012 (see also Rikala 2014a). The Literature Tree case explored the implementation of QR codes in the context of a Finnish primary school in Central Finland in October 2012 (see also Rikala 2014a). The subchapter will describe how the core-level aspects (i.e., context, time, and space) and medium-level aspects (i.e., learner, device, and social aspects) emerged in case studies. In addition, the subchapter will highlight other factors that emerged and either supported or hindered the implementation. The subchapter also emphasizes students' experiences and teachers' reflections.

Core-Level Aspects in the Math Trail Case

In the Math Trail case, the context in which the mobile devices and QR codes were used was interspersed with traditional classroom learning. The math problems were planned so that they had relevance to the school curriculum and, therefore, the implementation was not as authentic as it might have been. The math theory was taught with traditional teaching methods and in a teacher-centered approach, but along the Math Trail pupils worked at their own pace and in the ways that they preferred. However, the time when the mobile devices and QR codes were used was specifically designed (i.e., fit into math lessons) and consequently the activities were not spontaneous. QR codes were placed around the school surroundings. In other words, learning was extended outside the classroom. However, the Math Trail implementation can be arranged in a park, in a zoo, or almost anywhere pupils can discover and solve problems relating to what they find (Shoaf, Pollak & Schneider 2004). Thus, the study indicated that spatial and temporal restrictions occurred.

When examining the reasons why the core-level potentials were not fulfilled, the key elements were the teacher's competencies and beliefs. Even though the teacher's overall opinion of mobile learning was positive and she clearly had the ambition to change her teaching practices, the activity still remained didactic and teacher-centered, and the activity included practicing decimal problems with textbook-like tasks. For example, some inconsistency occurred. The teacher stated that when mobile technologies are integrated as a part of teaching, children think that the teaching and learning are more present-day and it is also easier to come closer to the children's everyday life. The teacher, for instance, highlighted:

> When you are considering this time and this life, then yes, you should take some good things as a part of teaching as well. (Teacher 3)

However, at the same time, the teacher also appeared to fear abusive or disruptive use of mobile technology and she stressed that mobile devices should be restricted only for educational purposes. The teacher also highlighted that she wants to keep things under control and that she does not have adequate ICT skills. Hence, these contradictory beliefs may be why the activity remained traditional and why the decimal problems were the same as the students were solving in the classroom.

The teacher also argued that many new and interesting technologies and opportunities were available, but teachers should have the opportunity to concentrate and learn how to integrate them into teaching and learning. According to this teacher, the Math Trail implementation clearly extended her thinking and led her to consider additional uses of mobile technologies. However, she also suggested that if Math Trails, QR code activities, and related items were included in and enclosed with the textbook or teacher's guide it would be easier for a teacher to organize a mobile learning activity. Thus, this indicates that the initiation of a mobile learning approach may be challenging for the teacher and therefore teachers would benefit from examples showing a teacher adapting his or her practices. Otherwise, the teacher may stick to traditional and familiar practices.

The teacher also argued that one major challenge for implementing mobile learning is the school's ability to provide necessary tools and devices. In this case, the equipment was loaned and therefore the mobile learning activity was possible. However, when considering the future, the teacher stated that the schools should purchase devices, because all students do not have the equipment required for mobile learning. According to the teacher, the factors that especially supported the mobile learning activity implementation were the students' skills and sufficient support. The teacher, for instance, argued that the threshold was reduced by the fact that the students knew how to use the equipment and there was an opportunity to receive support during the experiment.

Thus, when analyzing the contextual factors that support or challenge mobile learning integration, factors such as the teacher's competencies and beliefs as well as ICT infrastructure (e.g., devices and support) were observed. The Math Trail case also highlighted the importance of pedagogical practices and activity design. Specifically, in QR code activities, the teacher's contribution is significant as the teacher plans the situations in which QR codes are used, the learning goals, and contents and how learners will use the mobile technology to achieve the learning goals; no ready-made solutions are available. In this case, the teacher was inexperienced and wanted to keep things under control, which was also reflected in the activity design; the teacher resorted to familiar textbook-like problems. As a result, the core-level potential was not used and was not realized as assumed. Thus, the pedagogical choices were reflected in the mobile learning process and experience.

Core-Level Aspects in the Literature Tree Case

The Literature Tree case indicated that the core-level aspects (e.g., anywhere, anytime, authentic context) were not fulfilled sufficiently. In the Literature Tree case, the context in which the mobile devices and QR codes were used was interspersed with traditional classroom learning. The QR codes were particularly used to revise the lessons learned earlier. Along the trail, students worked at their own pace, as well as collaborated and solved problems together with their peers. The learning was extended outside the classroom, but it was still in a school surrounding, not in an authentic real-life context. The time when the mobile devices and QR codes were used was specifically designed and fit into mother-tongue lessons. Consequently, the activities were not spontaneous. One reason for this was the strict schedule. In this case, the implementation was carried out in a very short time (2 x 45 minutes); in other words, it was tied to the hourly schedule. Hence, the core-level potential (e.g., anywhere, anytime, authentic context) was not employed satisfactorily. Thus, spatial and temporal restrictions occurred. Both the Math Trail and the Literature Tree cases imply that the school environment and culture create challenges and limitations for true mobile learning implementation.

The activity also contained straightforward questions and, in a sense, yes-no answers; thus, it contained drill and practice activities. In the interview, the teacher trainees and teacher argued that the QR activity and its contents should have been designed differently. Furthermore, the lack of adequate feedback and some sort of competitive spirit obscured the real purpose of the activity. These discoveries highlight the importance of pedagogical design. More student-centered visions were shared in the interview. The teacher and teacher trainees, for instance, argued that the QR code activities should include applied exercises with the students' own output. The teachers argued that the students could design QR code activities for each other. They also stated that the technology should not be used only because it is technology, but rather because there is a clear pedagogical objective for its use. Thus, the teachers highlighted that mobile learning activity should extend traditional teaching and learning and offer something that is not possible to achieve with traditional teaching and learning resources. Another teacher trainee stressed:

> I always try to remember that the technology should not be used only for technology's sake. In a sense, there should be deeper meaning for why to use the technology. (Teacher 7)

The reason why all the core-level potentials were not employed related to the QR codes being new to the teachers and, therefore, teachers were not fully aware of the potentials and opportunities. The case study implementation, however, clearly inspired and raised many new ideas for possible future uses. This indicates that teachers benefit from examples of how to integrate mobile technologies with teaching and with other tools. The teachers also argued that the link between the device and their own pedagogy was somewhat loose because the technical implementation was done by the researcher. However, when the teachers realized that QR code generation is actually a simple task, they all said that they would like to learn how to generate the codes. The teachers also highlighted that the brief training session before the mobile learning activity was very important for them. The short training session, for instance, relieved some of their fear and anxiety. Thus, there clearly is a need for training.

The Literature Tree case also indicated that a positive experience and an open and curious attitude increased the teachers' courage to adopt the mobile learning approach. One teacher trainee, for instance, argued that it was nice to use devices that are familiar to students and to bring the students' world into school. She mentioned:

> I think that it was wonderful to use tools which are familiar to students and which students master. There were some boys who already downloaded the QR reader in their own mobile phones before the activity. I think that it is nice to bring teaching practices closer to the students' world. (Teacher 7)

Teacher 5 argued that some teachers might experience anxiety when something new is brought to school and might fear that students are better at using it than they are; however, the teacher also argued that it is important to accept the fact that sometimes students are better at utilizing technologies.

When considering future implementations, the school's ability to provide necessary tools and devices arises. In this case, the equipment was loaned, but in the future, the availability of the devices would be a significant factor in successful implementation. The teachers also speculated about the abusive and disruptive use of devices. However, in this case, the students' focus remained relatively strong during the activity. One teacher trainee, for instance, stated that the situation was not as chaotic as she had imagined beforehand, even though the device made possible misuse like playing games. Hence, the teachers were positively surprised about the implementation. Overall, the teachers were open and ambitious about changing their practices. For instance, they stated that technologies can be one way to develop their practices. However, sometimes inconsistency between teachers' expressed beliefs and their practices may occur (subchapter 3.5). Also in this case, the teachers' teaching practices did not transform significantly; they remained rather traditional. Overall, the case indicated that the contextual factors that support mobile learning are ICT infrastructure as well as the teacher's beliefs and his or her pedagogical practices.

Medium-Level Aspects in the Math Trail Case

The Math Trail case indicated that the medium-level aspects were achieved sufficiently. The case suggested that from a learner's point of view the Math Trail was fun and educational and brought variation to the traditional school day. The students strongly agreed that the QR activities were an interesting and exciting new way to learn mathematics and that they would like to do QR activities again (TABLE 17). Thus, the case study indicated that the Math Trail was motivating for students. The mobile technologies' ability to motivate students has also been highlighted in earlier studies (subchapter 3.5).

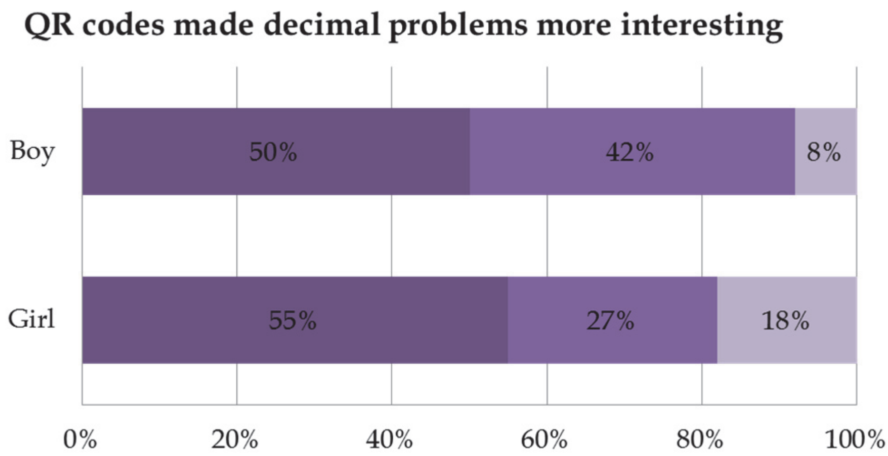
TABLE 17 Primary school students' feedback about learning with QR codes (n=23)

	Yes	No
I would like to do QR activities again.	100%	-
QR activities were an interesting new way to learn mathematics.	100%	-
I prefer traditional teaching and learning methods.	-	100%

Also, the teacher was highly satisfied with the experiment. She argued that the Math Trail clearly inspired and motivated students. The teacher presumed that the students' motivation emerged from their autonomy as they could control the pace at which they learned and were able to solve challenging tasks in an interesting way instead using the traditional textbook training. Thus, the learning experience was personalized for students. Also, the literature (Chapter 3) has highlighted that mobile learning can support personalized learning where students can choose the place, pace, and time when they learn and as a consequence, enjoy autonomy over their learning content.

All the students found the new teaching and learning methods more attractive than the traditional (TABLE 17). The new way to learn mathematics especially seemed to inspire and motivate boys, but girls were also engaged and claimed that QR codes made decimal problems somewhat or a lot more interesting (FIGURE 23). When asked for their opinion about the experiment, 14 students out of 24 remarked that they thought the experiment was fun. However, according to student feedback, there should be a wide range of math problems, as two students found the problems too easy. One student, for instance, argued:

> It was an interesting new way to learn, but the math problems could have been more difficult. (Respondent 14; a boy)



	Girl	Boy
A lot	55%	50%
Somewhat	27%	42%
Not at all	18%	8%

FIGURE 23 QR codes made decimal problems more interesting (n=23)

Thus, the Math Trail served most of the students' needs. However, two students couldn't participate because they received remedial or special-needs education in mathematics. The QR code implementation was too difficult for these two students. The teacher stated:

> It did not occur to me when we were planning this Math Trail that these two students would not be able to participate because they progress slower. In retrospect, there should have been even more variation in the math problems. Now there was quite a strong dissimilarity experience for these two students and that was not good. (Teacher 3)

In other words, by designing a wide range of tasks, the Math Trail can be personalized to serve different types of learners and even students who receive remedial or special-needs education. In this experiment, however, the special needs of the two students were not taken into account adequately in the planning process. These discoveries clearly highlight that it is important to know learners' needs and preferences. Hence, the case study highlighted that students' motivation can suffer if they encounter problems or if the math problems are not challenging enough or are too bewildering for them. As a two-week experiment, the Math Trail activity indicated that students' motivation is maintained if the Math Trail problems are suitable and sufficiently challenging. In this experiment in particular, the suitable and challenging problems encouraged the students to persevere in solving them. The teacher argued:

> In the second part of the trail the problems were somewhat more challenging and demanding, but it was also more inspiring for the students. The children really liked and tried to complete the trail. (Teacher 3)

The study also indicated that the Math Trail was educational (TABLE 18);

TABLE 18 Students' self-evaluation of learning (n=23)

Students' self-evaluation of learning	Examples of students' questionnaire answers
I learned mathematics with QR codes.	- I learned to solve decimal problems a little bit better. (Respondent 1; a boy) - It was easier to solve math problems with QR activities. (Respondent 2; a boy) - Well, mathematics better. (Respondent 3; a girl) - Solving math problems better. (Respondent 9; a girl) - I learned to solve different kinds of decimal problems. (Respondent 10; a girl)
I did not learn anything new.	- Nothing much (Respondent 6; a boy) - I did not learn anything because I already knew how to solve them. (Respondent 14; a boy) - Nothing new. (Respondent 16; a girl)
I learned to use a smartphone.	- I learned to use a different kind of smartphone. (Respondent 4; a girl) - I learned to navigate and to use a smartphone. (Respondent 5; a girl) - To solve decimal problems and to use a smartphone. (Respondent 18; a girl)

50% of the students highlighted in their open-ended answers that they had learned mathematics with QR codes However, 38% of the students claimed that they did not learn anything new with QR activities. The boys claimed more often than girls that they did not learn anything new. Three students also highlighted in their open-ended answers that they learned to use a smartphone better. Thus, the study indicated that with the mobile learning approach it is possible to learn both contents and technical skills. The reason why some students claimed that they did not learn anything new may be because in this case the mobile learning activities were textbook-like decimal problems that the students were already solving. Hence, the learning in the mobile learning activity was to a great extent drill and practice-based rehearsing and, thus, it is not surprising that some students suggested that they did not learn anything new. However, the teacher said that along the Math Trail students even solved problems that she had not yet taught them. This was because the students were able to move at their own pace and some students proceeded faster than the teacher assumed they would.

The study also implied that increased learner motivation, persistent attempts, and practicing decimal problems had an effect on students' test grades. The students' test grades were generally good (TABLE 19).

TABLE 19 Students' test grades[15] in Math Trail case (n=24)

Grade	Frequency
4	-
5	-
6	-
7	1
8	6
9	10
10	7

This assumption that the implementation had an effect on students' test grades is mainly based on the teacher's arguments. The teacher was slightly surprised that the students' test results were good even though textbook practicing was reduced. In an email after the experiment, the teacher mentioned:

> Although we practiced less than normal, something more happened in the students' brain. (Teacher 3)

Thus, the teacher's arguments suggest that the QR implementation encouraged the students to persevere in solving the problems, which possibly also led to deeper knowledge. In the interview, the teacher especially highlighted the importance of the different approach that deviated from students' routine exercises. The textbook practicing took on a new shape. According to the

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15 In the Finnish primary school, the students' test results are evaluated using a scale from 4 to 10 where 10 is excellent and 4 is fail.

teacher, it was also important to extend the learning outside the classroom and combine movement with learning. Overall, the Math Trail case indicated that this novel approach had a positive impact on learner motivation and thereby also possibly on learning outcomes (TABLE 19). As noted earlier, this is based on observations made from the data and mainly based on the teacher's argument; thus, it should be verified, for example, with an approach like a pre-test and post-test.

The mobile device brought some challenges to the learning process, which related primarily to device usability. The students strongly agreed that it was easy to use QR codes but somewhat disagreed that the QR code reader or phone always functioned as they wanted and expected (TABLE 20). Only 26% of the students had used QR codes before the experiment (TABLE 20). This might be why some students experienced problems with the QR code reader. Another problem was related to the QR code reader itself. The software selected and used for decoding the QR codes was slightly unsteady and some students grew impatient with it. Similar problems were also observed in earlier experiments (Rikala & Kankaanranta 2012), but it was not obvious whether the problems related to the software or the users' skills. The same problems, however, recurred; the software was unsteady and the decoding became difficult. After the experiment, for example, one student wrote:

> The Math Trail activity was fun, but sometimes when I was scanning the code, the code reader became blurry. (Respondent 3, a girl)

Therefore, in the future, it would be reasonable to test various QR code readers to find intuitive readers that support and promote the learning process. The necessity for ease in use and intuitive devices and applications has also been highlighted in the literature (subchapter 3.5).

TABLE 20 Primary schools students' feedback about using QR codes (n=23)

	Yes	No
It was easy to use QR codes.	100%	-
The QR reader always functioned as I wanted.	35%	61%
I had already used QR codes before this activity.	26%	74%
The phone always functioned as I expected.	39%	61%
I had to learn many things before I learned how to use the phone and mobile applications.	13%	87%
I own a mobile device.	100%	-

Furthermore, the scanning of QR codes became more difficult depending on the circumstances. The teacher, for instance, reported that a rounded surface interfered with scanning of the QR codes. Also, lighting conditions interfered with the scanning; the teacher stated that the students could not scan the codes if they were in too dark a place.

Another significant challenge related to device usability was the loaned smartphones (Nokia 5800 XpressMusic). These phones are a few years old and have been used in several experiments; this clearly had an effect on their reliability. Students claimed that the smartphones did not always function as they expected; 61% of the students disagreed with the statement: *The phone always functioned as I expected* (TABLE 20). However, according to the teacher, the phones functioned surprisingly well and only once or twice did the battery charge run out during the Math Trail or the students report problems. According to the teacher, the students also instantly learned how to use the loaned smartphones and QR code reader. Only a few students had problems and needed help during the experiment. This is consistent with the survey results, as only 13% of the students expressed that they had to learn many things before they learned how to use the phone and QR code application; also mobile devices were familiar to the students, as all of the students reported owning a mobile device (TABLE 20). Technical problems naturally had an effect on the students' overall learning experience, but not inauspiciously as all students stated that they would like to do QR activities again (TABLE 17). The students' experiences, however, clearly highlight the importance of device usability. The encountered problems with technology, at worst, may frustrate the students and distract them from the learning process.

The study also indicated that the Math Trail activity encouraged social interactions. The Math Trail was planned as an independent activity but cooperation was allowed. Each student solved problems in his or her preferred way and pace. However, according to the teacher, the students also regularly formed groups and solved problems together. Therefore, the study indicated that the Math Trail supported both independent and collaborative learning. However, in this activity, the mobile technology was not used to mediate collaboration and, therefore, the social aspect is slightly questionable.

Medium-Level Aspects in the Literature Tree Case

The medium-level aspects were also fulfilled sufficiently in the Literature Tree case. The Literature Tree case indicated that from a learner's point of view the QR activity brought variation to the traditional school day; 75% of the students agreed that the activity was an interesting new way to learn and more than half (63%) of the students stated that they would like to do QR activities again (TABLE 21).

TABLE 21 Secondary school students' feedback about learning with QR codes (n=16)

	Yes	No	Missing answers
I would like to do QR activities again.	63%	25%	2
QR activities were an interesting new way to learn.	75%	19%	1
I prefer traditional teaching and learning methods.	25%	50%	4

Also, 50% of the students found these types of new teaching and learning methods more attractive than traditional ones (TABLE 21). When asked about the experiment, eight of 16 students stated that they thought the experiment was fun. However, some of the boys criticized the experiment. Also, the observations during the experiment indicated that some boys' attitude was negative and that boys were more interested in what else could be found in the phone.

The negative feelings were probably why girls claimed more often than boys that QR codes made literature history refresher tasks more interesting (FIGURE 24). Despite some students' negative feelings, most of the students found the activity interesting and were engaged by it. The teacher was also positively surprised about the student participation. She ruminated:

> Even though these are very familiar students for me, I learned new things about them. I noticed that a student who otherwise is quiet and does not participate much can act totally different in this kind of activity. It is always positive when you can find something that motivates and interests students. (Teacher 5)

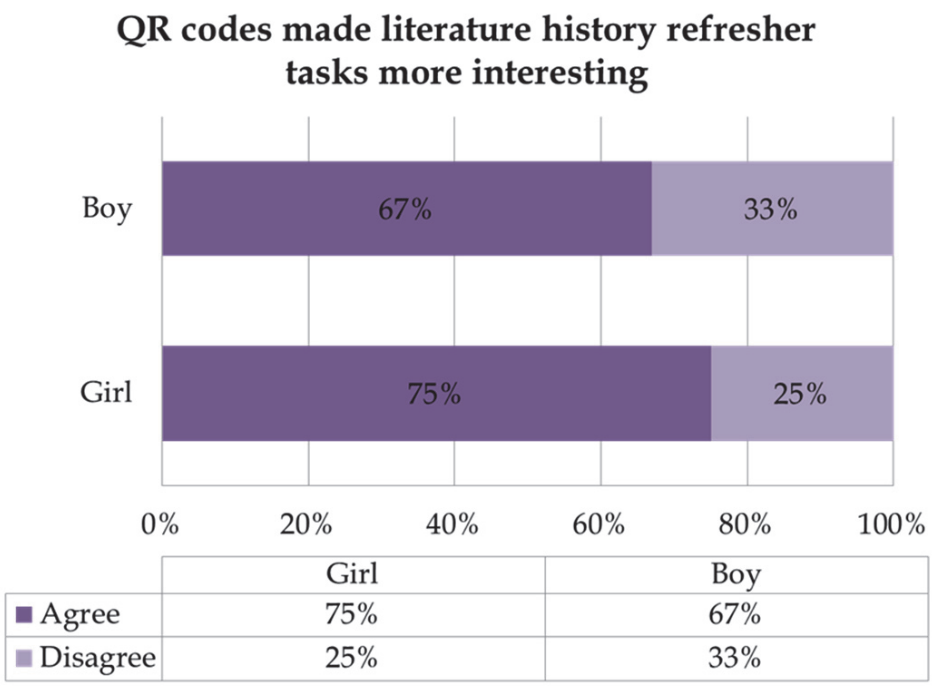

FIGURE 24 QR codes made literature history more interesting (n=14)

The teacher and teacher trainees further stated that the activity was suitable for revising lessons learned earlier. In particular, the versatility of the codes was considered very positive and was praised by the teacher and teacher trainees. One teacher trainee reflected on the activity:

> QR codes certainly are suitable for many things, but I think that those suit particularly well in our Literature Tree activity because we were able to utilize diverse images and text samples. (Teacher 7)

The teacher trainees also observed that during the QR activity the lessons learned earlier were reflected in the trail and conversely the things revised in the trail were remembered after the activity as well as conjoined with what had already been learned. The teacher (Teacher 5), however, argued that it is very difficult to specify how the QR code implementation affected the students' test grades. Nonetheless, she added that the implementation definitely refreshed learning and, therefore, the subjects might be more memorable to the students. The teacher and teacher trainees also highlighted that QR codes can attract and serve a wide range of learners and that extending the learning outside the classroom may be important for many learners.

The activity also offered many opportunities for personal instruction and feedback, but they were not utilized. Another teacher trainee reflected:

> One big thing that was missing was proper feedback. In these kinds of trails there should be much more time for feedback and the way feedback is given should be planned beforehand. (Teacher 6)

The lack of sufficient feedback also led to students perceiving the trail more like a competition than a learning activity. The teacher argued:

> There certainly was a spirit of competition and the students tried to finish the trail as quickly as possible. I do not know whether we should blame the content or we can really blame anything. Perhaps that is an intrinsic feature of this kind of activity. (Teacher 5)

Thus, from a learner's point of view the activity brought variation to the traditional school day and most of the students found the activity interesting and motivating. However, it is not obvious why some students perceived the trail more like a competition and why some students' feelings were negative. One possible explanation is that students are accustomed to studying with traditional methods because teaching and learning in many cases is still rather traditional, that is, textbook-centered, subject-based, and academic in nature (Chapter 1). Therefore, this kind of implementation may feel more like play and competition. This assumption gets some support from the student survey. As much as 25% of the students argued that they prefer traditional teaching and learning methods (TABLE 21).

From a device point of view, there were again some challenges with the loaned mobile devices. The students strongly agreed that it was easy to use QR codes but somewhat disagreed that the QR code reader always functioned as they expected (TABLE 22). Only 38% of the students had used QR codes before the experiment. This might be why some students experienced problems with the QR code reader. Even though mobile devices and their use are familiar to the students (e.g., all the students owned a mobile phone), the QR scanning raised a lot of questions among the students.

TABLE 22 Secondary school students' feedback about using QR codes (n=16)

	Yes	No	Missing answers
It was easy to use QR codes.	94%	-	1
The QR reader always functioned as I wanted.	38%	56%	1
I had already used QR codes before this activity.	38%	63%	
The phone always functioned as I expected.	56%	44%	
I had to learn many things before I learned how to use phone and mobile applications.	-	100%	
I own a mobile device.	100%	-	

Another clear problem was related to the QR code reader itself. The software that was used for decoding the QR codes was slightly unsteady and some students grew impatient with it. This challenge was also observed in the Math Trail case, but because the case studies were almost simultaneous, it was not possible to resolve the problem in situ.

Furthermore, the scanning of QR codes became more difficult depending on the circumstances. During the experiment, some of the lamps in the corridor were out of order. The dark corridor made the scanning somewhat more challenging. The teacher trainees tried to help the situation with flashlights but this appeared to make the scanning even more difficult. Also, the Math Trail case indicated that the scanning of QR codes became more difficult depending on the circumstances. Thus, based on these observations, it is important to ensure propitious circumstances for the scanning of QR codes in advance, if possible.

Another challenge, mentioned earlier in the Math Trail case description, was the loaned smartphones (Nokia 5800 XpressMusic) and their reliability. Nearly half (44%) of the students claimed that the smartphones did not always function as they expected (TABLE 22). Also, observations made during the experiment indicated problems with the phones. Particular, a great number of difficulties arose with the data connection. However, according to the teacher and teacher trainees as well as observations, the use of QR codes for the most part was not difficult and students quickly learned how to use the loaned smartphones as well as the QR codes. Another teacher trainee argued:

> It was not difficult, actually quite simple, and the students also realized the use instantly. (Teacher 6)

This is consistent with the survey results as none of the students expressed that they had to learn many things before they learned how to use the phone and QR code reader (TABLE 22). Technical problems naturally had an effect on the students' learning experience but not inauspiciously as 63% of the students reported that they would like to do QR activities again (TABLE 21). Nevertheless, the students' experiences clearly indicate the significance of device usability.

In the Literature Tree activity, the entire activity was planned around cooperation. The students solved problems in small groups and, according to the researcher's observations, actively advised each other when they encountered problems. Helpful discussions also occurred from time to time despite the spirit of competition. Based on the observations, this discussion clearly helped students in constructing their arguments and determining their answers. Therefore, based on the observations, the Literature Tree activity clearly encouraged social interactions and collaboration.

5.2.2 Reflecting the First Evaluation Cycle

The first two case studies indicated that the core-level aspects were challenging. Mobile device usage was interspersed with traditional classroom learning. Therefore, spatial and temporal restrictions occurred. Mainly, these restrictions were based on a strict schedule.

The medium-level aspects were fulfilled somewhat sufficiently. The mobile learning activities were motivating for students and the mobile application also supported the learning process although some minor technical problem occurred. The mobile learning activities also encouraged social interactions.

In addition, the first two case studies highlighted the importance of pedagogical practices. Teachers' pedagogical choices were reflected in the mobile learning process and experience. The teachers resorted to familiar activities and thus the core-level potential was not fulfilled as assumed. Also, the earlier short pilot tests (Rikala & Kankaanranta 2012) highlighted the importance of pedagogical practices and design. Thus, the pedagogical aspect must be incorporated into the framework.

Contextual factors such as ICT infrastructure as well as the teacher's beliefs and competencies were also observed and should be investigated in more detail. Both the challenging core-level aspects and the promising medium-level aspects should be investigated further.

5.2.3 Revising the Initial Mobile Learning Framework

Based on the first two case studies in the first evaluation cycle, the pedagogical aspect (i.e., pedagogical practices) was added to the framework (FIGURE 25) and taken under scrutiny (see also Rikala & Kankaanranta 2014b). The earlier pilot studies (Rikala & Kankaanranta 2012) and the literature (Chapter 3) have emphasized that the pedagogical aspect is significant. The first two case studies particularly highlighted that the teacher's pedagogical practices and the activity design influence the core- and medium-level aspects and how those are realized.

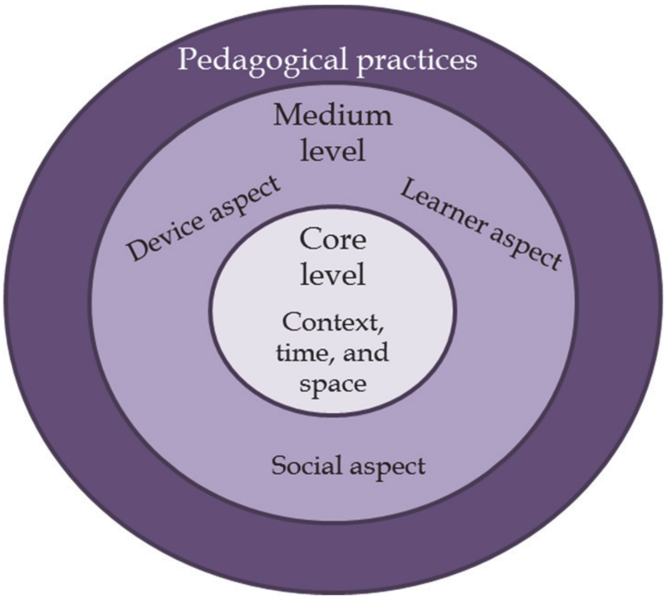

FIGURE 25 Revised version of the mobile learning framework based on the first evaluation cycle

5.2.4 Second Evaluation Cycle

The first revised version of the mobile learning framework (FIGURE 25) was evaluated with one case study, the Nature Tour case. All four case studies were nearly simultaneous, but the Nature Tour case followed the Math Trail and Literature Tree cases and, therefore, it was sensible to select it for evaluation. In the Nature Tour case, two early childhood education groups used the Nature Tour mobile application for two months in the fall of 2012 (see also Rikala & Kankaanranta 2014b). The observations made about core-level aspects, medium-level aspects and pedagogical practices are described in the next sections.

Core-Level Aspects in the Nature Tour Case

In the Nature Tour case, the core-level aspects (e.g., anytime, anywhere, authentic context) proved to be slightly challenging. The context in which the Nature Tour mobile application was mainly used was field trips, but the teachers also reported that they used it indoors and when they documented the phenomena of the first snow. Hence, the learning was applied appropriately in real-world contexts. The teachers also argued that the Nature Tour mobile application extended learning beyond the traditional learning space in a motivating way. Both teachers also reported that they organized several field trips for their groups during the school year but that the field trips so far had been less structured and included more play as well as physical exercise. The teachers, therefore, argued that the device and application clearly directed the children's attention to nature.

The frequency of application use was not very high during the two months. One of the teachers (Teacher 1; see TABLE 14, 97) stated that she only used the application three times with her group and the other teacher (Teacher 2; see TABLE 14, 97) said that she used the application several times but not every day. According to the teachers, use of the application was not specifically designed, but instead the activities were rather spontaneous. The children were also able to take pictures without restrictions. However, the time when the application was used (i.e., field trips) was arranged according to a schedule. According to the teachers, this was mainly because the preschool groups have plenty of other activities during the fall. Hence, unfortunately, the implementation was not as spontaneous as it might have been. At best, a child could use the application whenever the need arose (e.g., when the child saw the first flower of spring). Even though all the core-level aspects were not fulfilled as assumed, the Nature Tour case was closer to the ideal in mobile learning because the learning was extended to an authentic context in nature and the children were able to document what they wanted. Nevertheless, the Nature Tour case also had some challenges.

When studying the contextual factors that supported or challenged the implementation, the teacher's competencies arose. Based on the teachers' interview, the integration was difficult because the teachers' did not have sufficient skills. Both of the teachers argued that they definitely would need more training. Also, policy-level support was mentioned. The teachers should be provided with resources and time to train and change their practices. One teacher stated:

> I would definitely have interest to integrate technology into teaching practices, but the employer should provide some resources and time. When you have other required tasks, the enthusiasm can fall apart, especially if you have to spend your own free time to practice as well as if you are not technically oriented or skilled. (Teacher 2)

This lack of confidence was reflected in the interview. Because of this lack of confidence, the teachers opened the application for the children. They feared that something could go wrong and thus they set things up in advance. The lack of adequate skills and confidence were reflected in the teachers' overall experience as well as their readiness and willingness to adopt a mobile learning approach again. When considering future implementations, the availability of technology was also mentioned as a key factor. When asked about available ICT and ICT use in early childhood education in general, one teacher stated:

> Mobile devices are not available in our municipality at the moment. Some early childhood groups have experimented with how the interactive and electronic whiteboards could be utilized... Hence, the interest clearly exists. There are also some doubts about whether ICT is suitable for preschool or not. Some are fascinated and some simply marvel. (Teacher 2)

Thus, the Nature Tour case highlighted the need for supportive settings as well as adequate teacher competencies as contextual factors that may support mobile learning implementation.

Medium-Level Aspects in the Nature Tour Case

In the Nature Tour case, the medium-level aspects were fulfilled sufficiently. In particular, the learner aspect was realized surprisingly well. However, the information in this case is second-hand information; in other words, the children's experiences were related by their teachers. According to the teachers, the field trips were motivating and meaningful to the children. The teachers also stated that the mobile device was an inspiring and motivating element for the children. The mobile application inspired the children to look at their surroundings in novel ways. They observed their surroundings and tried to find interesting places and things to photograph. New things began to interest them. One teacher stated:

> Various fungi, for instance, began to interest the children. (Teacher 2)

Also, the children's creativity was reflected in their pictures as some of the observation pictures were very imaginative or artistic (FIGURE 26).

FIGURE 26 Examples of children's observation pictures

According to the teachers, the children became very sensitive in observing nature and its phenomena. The teachers reported that the children observed nature and paid attention to plants, fungi, and other interesting natural phenomena and creatures. Some of the children even tried to identify species independently. This case, therefore, indicated that the mobile application clearly offered the children new perspectives. The teachers argued that the children had never paid as much attention to nature as during the field trip. The mobile application thus opened up a whole new world for the children and they began to construct knowledge and awareness of nature. One of the teachers mentioned:

> The children observed nature more closely. For instance, they noticed the flowers: "Hey! Here are still growing some flowers. I will take a picture." Normally, probably, no one would even notice the flowers. (Teacher 1)

The assistant, in turn, remarked:

> The experiment opened my eyes for the present day, for discovering what the children's world is today and what it is going to be. (Assistant)

Thus, the Nature Tour case study indicated that the use of mobile applications can enhance children's interest and motivation.

The device aspect was again slightly challenging; according to the teachers, during the experiment various technical problems arose which were difficult to solve alone. The teachers, however, were able to describe only two problems in detail. One clear problem, according to the teachers, was related to the differences in appearance of the mobile phone screens. An assistant mentioned:

> The phones did not always open in the same way. There was, for example, a variety of questions that appeared in the screen. So, how on earth could you give the phone to a child who cannot read? (Assistant)

Another problem was related to reliability; sometimes, the phones functioned very slowly, especially when saving data. One of the teachers stated:

> What in our case was causing some confusion was when the phone said "saving." The children were confused. I said to just wait for a moment. It, however, took some time before the children learned that it takes some time before it is possible to take another photograph. (Teacher 1)

According to the teachers, other technical problems also arose during the implementation. However, the teachers were not able to identify these problems more precisely. The encountered problems especially reduced the teachers' desire to use the application and they also experienced the application as difficult to use. These observations clearly indicate that device usability strongly influences the experience, perceived ease of use, and perceived usefulness of the mobile device. Thus, the case study indicated that the device aspect and especially device usability play key roles in mobile learning implementation. The problems encountered with the device also led to the children not being able to use the application independently. In Finland, children start compulsory education at age 7 and the majority of the children learns to read during their first year of school. Because the application required literacy skills, and the appearance of the mobile phones varied, the teachers thought that they had to open the application to the state where the child could take pictures. However, the teachers believed that the children could learn to use the application quickly and added that they simply did not have adequate skills to guide the children in using the application. These findings indicate that the teachers' need sufficient technological skills and support for the effective use of technology.

Also, the social aspect was realized relatively well. The mobile application clearly encouraged social interaction, especially with adults but also with peers. The teachers said that the children compared pictures and advised each other on where to take beautiful pictures. The children also interacted with the teacher by asking about the species. All the children eagerly asked for the names of the species. The social aspect, particularly in early childhood education, is significant because technology cannot replace human interaction or relationships. Thus, teachers teach, but the technology does not. It was encouraging to find that the Nature Tour mobile application stimulated interactions with both peers and adults.

Pedagogical Practices in the Nature Tour Case

The teachers highlighted that they did not know how to integrate use of the application in daily life and other materials. One of the teachers reflected:

> The fact is that we already have plenty of material that we are using here. If something new is brought and it is just in a way "glued" on top of all that, it does not integrate easily, especially if you are not technically skilled. I think that this is the biggest challenge in our case. (Teacher 2)

Specifically, the lack of necessary skills to integrate the mobile application in daily life and as a part of pedagogical practices was the main reason why the application remained a tool for photographing various things. The teachers mentioned that they just went to the field and took some pictures. The teachers also considered that use of the application and follow-up activities should be planned in a more detailed manner and integrated into certain topics. In other words, there should be a clear pedagogical objective for each field trip. With regard to pedagogical planning, one of the teachers stated:

> If we started to use this application, then it would require more detailed planning. (Teacher 2)

Thus, the difficulty of integrating use of the application with other activities was due to the lack of necessary skills. The teachers did not have adequate knowledge about how best to integrate technology into the curriculum and pedagogy as technology use in early childhood education in many places is a novelty or seldom used. The teachers emphasized that the use of information technology cannot become a part of daily routines until the teachers have adequate training. The need to transform teachers' education, for instance, was brought up and highlighted in the conversation. Thus, the Nature Tour case clearly highlighted the importance of pedagogy, the need for sufficient support (both technological and pedagogical), and examples as well as training to effectively use technology.

5.2.5 Reflections on the Second Evaluation Cycle

The observations made about the challenging core-level aspects in the first three case studies in two evaluation cycles evoke the idea that core-level aspects such as authenticity and spontaneity are actually characteristics of the overall mobile learning experience and that they are a result of the mobile learning activity design and mobile learning process. Even though the Nature Tour case was closer to ideal mobile learning as it extended learning to an authentic context, the core-level aspects were still not fulfilled sufficiently. Temporal restrictions occurred and, therefore, learning was not as spontaneous as it might have been.

The first three case studies also highlighted that the problems with technology may reflect on the mobile learning process and how it is experienced. In the Nature Tour Case, the problems with technology particularly reflected the teachers’ experience and confidence. Otherwise, the activities were motivating and meaningful to the children and also encouraged social interactions. Thus, the medium-level aspects were fulfilled somewhat sufficiently. However, the three case studies in two evaluation cycles also evoked the idea that the medium-level aspects should intersect. Based on the three case studies, medium-level aspects also appear to be central to the mobile learning process. The Nature Tour case study also indicated that the pedagogical aspect is significant and should be kept in the framework.

5.2.6 Revising the Mobile Learning Framework

Based on the observations made in first three case studies in two evaluation cycles, the framework was again revised. The revised version separates the mobile learning process and the mobile learning experience and highlights pedagogical practices (FIGURE 27).

In the revised version of the framework, pedagogical practices play a bigger role. The pedagogical aspect was added to the framework because the first three case studies, the earlier mobile learning pilot test (Rikala & Kankaanranta 2012), and the literature (Chapter 3) indicated that the pedagogical aspect is significant. In the revised framework, pedagogical practices particularly culminate in mobile learning activity design and also affect the mobile learning process and the mobile learning experience. In particular, the second evaluation cycle highlighted the importance of a clear pedagogical objective and, therefore, the pedagogical practices have been raised to the center of the framework.

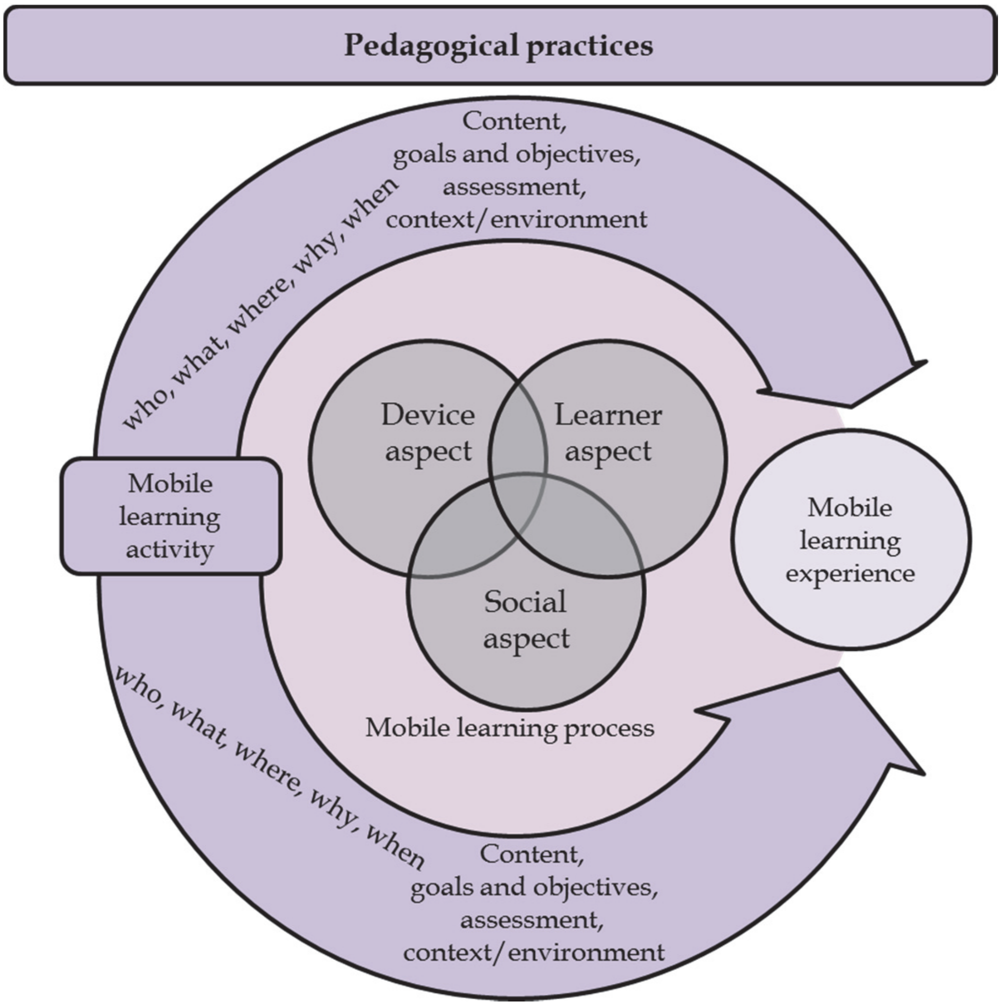

FIGURE 27 Revised version of the mobile learning framework based on the second evaluation cycle

The first two evaluation cycles also indicated that the learner, device, and social aspects are central aspects in mobile learning. These aspects have also been highlighted in the literature (Chapter 3). In the revised version of the framework, these aspects intersect, which means that when learners conduct mobile learning activities, they can move within different physical and virtual locations and participate and interact with each other, information, and systems. This intersection is also described in Koole's (2009) FRAME model. Thus, the balance of these aspects is important. For instance, challenges with a device may be reflected in the mobile learning process and the mobile learning experience, as highlighted in the first three case studies. The technical challenges clearly reflected learners' (and teachers') physical and psychological comfort levels.

Characteristics such as authenticity and spontaneity (which in the initial mobile learning framework were seen as core-level aspects) are seen as the result of mobile learning activity design as well as the mobile learning process. For instance, based on the two evaluation cycles, teachers' decisions about where and when mobile devices are used affect the authenticity and spontaneity. In the first two cases in the first evaluation cycle, the learning was interspersed with traditional classroom learning. In the third case in the second evaluation cycle, the learning was extended outside the classroom to authentic contexts. However, because of the strict schedule, neither of the cases was as spontaneous as it could have been. Thus, school culture clearly created some restrictions.

5.2.7 Third Evaluation Cycle

The second revised version of the mobile learning framework (FIGURE 27) was evaluated with one case study, the Leaf Structure case. As emphasized earlier, the case studies were conducted nearly simultaneously. Therefore, the Leaf Structure case was selected as the case for the third evaluation cycle. In the Leaf Structure case, 19 2nd grade students (aged 7-8 years) and their teacher (Teacher 4) participated in a half-day experiment in October 2012. The observations made about pedagogical practices, the mobile learning process, and the mobile learning experiences are discussed below.

Pedagogical Practices in the Leaf Structure Case

In the Leaf Structure case, the learning was extended outside the classroom into nature. The objective was to explore and learn local area trees and especially their leaves. According to the teacher, the pedagogical approach to the activity was discovery learning. Discovery learning is discussed in more detail in subchapter 3.4.5. The teacher reported that the clear pedagogical objective helped to focus the field trip and activity. The easy to use device further supported the implementation. The students concentrated on the task, not other irrelevant things or the device. The teacher also argued that it was easier to guide students to search and observe nature with a more goal-oriented activity. The teacher reflected on the clear pedagogical goal:

> Children's attention was drawn to nature surprisingly well because the use of the device and instructions were clear to the students. (Teacher 4)

In the field, the students constructed their own material and worked at their own pace. Use of the application was also linked to classroom teaching and learning as the observation photographs were used after the field trip to advance students' knowledge of trees and tree leaves. Thus, the activity blended traditional teaching and learning. The teacher described the course of the activity as follows:

> After the field trip, we printed the photographs and students tried to identify the trees. The students were also asked to draw structural drawings, name the trees, as well as build a memory game. (Teacher 4)

According to the teacher, implementing the mobile activity and linking the mobile application as a part of daily routines were easy. The teacher also argued that the mobile application gave students an opportunity to work in different ways inside and outside the classroom. He stated:

> The application enabled the implementation of a traditional field trip in a different way. (Teacher 4)

The teacher further argued that the mobile application use was convenient and beneficial in terms of teaching and learning and that the mobile device can be used to diversify learning activities.

Thus, the Leaf Structure case indicated that the use of technology requires a balance among the curricula, student's needs, and human interactions, in other words, pedagogy. Therefore, the study indicated that pedagogical practices influence the learning activity, the mobile learning process, and the mobile learning experience. Hence, the mobile device or application by itself does not ensure a meaningful learning experience for children. The ways in which the mobile devices are used and how their use is associated with pedagogy are equally important. In this case, mobile device usage was adapted meaningfully as a part of teaching and learning. The mobile device use was a part of the learning continuum which included multiple learning tasks. Hence, the activity as a whole afforded a tailored and motivating experience for the children.

Mobile Learning Process in the Leaf Structure Case

The mobile learning process focuses on the learner, device, and social aspects. Therefore, the following paragraph describes how these aspects were reflected in the Leaf Structure case. The teacher argued that the mobile learning application suited all the students well and there was no need to adapt the use of the application in any way. The application also clearly increased student motivation as every student could easily record his or her own observations during the field trips. The benefits that the teacher especially highlighted in his answers were related to the study motivation. The teacher argued:

> The students were able to work with their own material, and this clearly increased the student interest and motivation. (Teacher 4)

The teacher added that one of the best experiences for him was observing the students' enthusiasm and that the students were skilled and used the mobile application without problems. Overall, the students appeared to be very curious about the new approach that deviated from their routine exercises. Nearly all (95%) of the students reported that they would like to use the Nature Tour mobile application again and all of the students agreed that taking photographs with the mobile application was fun. About 89% of the students reported that use of the mobile application was interesting (TABLE 23).

TABLE 23 Primary school students' feedback about learning with Nature Tour mobile application (n=19)

	Agree	Disagree
I would like to use the mobile application again.	95%	5%
Use of the application was interesting.	89%	11%
Recording observations with the mobile application was fun.	100%	0%

The students found that the application was easy to use; approximately 89% of the students agreed with the statement that the Nature Tour mobile application was easy to use. In addition, according to the teacher, the students told him that the application was easy to use. This is consistent with the questionnaire answers (TABLE 24). The teacher stated that no major technical problems occurred during the experiment. The students' answers, however, indicated that some minor problems with the reliability of the loaned equipment occurred; 47% of the students disagreed with the statement: *The smartphone always functioned as I wanted* and more than half (58%) reported that they needed help with the application (TABLE 24). Similar kinds of reliability challenges were also observed in earlier cases.

TABLE 24 Primary school students' feedback about the Nature Tour mobile application (n=19)

	Agree	Disagree
I think that the application was easy to use.	89%	11%
The smartphone always functioned as I wanted.	53%	47%
I needed help with the mobile application.	58%	42%

These minor problems with devices, however, did not interfere with the field trip; as the teacher reflected:

> The field trip went well and the students liked to use the mobile application. There were no problems. (Teacher 4)

However, based on the Leaf Structure case, the students experienced problems, especially with the loaned phones. The results might have been different had the students used their own equipment. Nevertheless, the findings clearly highlight the importance of ensuring that the equipment functions smoothly. Thus, the device and application should be easy to use and intuitive enough to be suitable and attractive for learners. This has also been emphasized in the literature (subchapter 3.5). Specifically, the Leaf Structure case indicated that even small problems are reflected in the overall learning experience. Thus, device and learner aspects are clearly intertwined.

In the Leaf Structure case, the mobile technology was not used to mediate collaboration or social interactions. However, according to the teacher, the students eagerly showed their photographs to him after the field trip. The case study therefore indicated that the mobile application encouraged social interaction with the adult. Thus, it was encouraging to find that mobile activity can enhance social interactions. However, as highlighted in the literature (subchapter 3.5), social interactions should be taken into account.

The observation photographs recorded during the field trip were also used to acquire knowledge after the field trip. The activity thus combined and blended both virtual and physical contents and spaces. Koole (2009) highlighted that in mobile learning learners may move within different physical and virtual locations and participate and interact with other people, information, or systems. Thus, the device, learner, and social aspects intersect (subchapter 4.1). In this case, the three aspects appeared to be in balance, especially because the activity was well planned and, therefore, the mobile learning process moved forward effortlessly. The teaching and learning were not bound to the device or application. The device and application were adapted meaningfully as a part of the learning continuum, which also included several tasks and other aids such as structural pictures of tree leaves. The significance of integrating mobile learning as a part of the learning continuum has also been stressed in the literature (subchapter 3.5).

Mobile Learning Experience in the Leaf Structure Case

This subsection highlights the mobile learning experience and discusses how aspects such as personalized, spontaneous, and authentic are present. All things considered, the Leaf Structure case indicated that the overall learning experience was meaningful, personalized, and motivating for the students. In the field, the children were able to work at their own pace and photograph things they wanted. The students were motivated to observe nature and record their observations. The teacher reflected:

> The students wanted to make observations and take good pictures without the teacher having to command or supervise them. (Teacher 4)

The student enthusiasm was also reflected in the survey answers as the students overall estimation of the activity was very positive. Nearly 70% of the students (69%) thought that the activity was excellent and 16% thought that the activity was satisfactory. None of the students reported not liking the activity. Thus, the Leaf Structure case indicated that the learning experience was motivating and meaningful to most of the students. It provided a tailored learning experience and the children being able to work with their own materials increased student engagement.

The spontaneity aspect was again somewhat challenging because the activity was organized according to the class schedule. Thus, temporal constraints existed. However, the learning was extended to an authentic context in nature and students were able to work at their own pace. Therefore, the Leaf

Structure mobile learning activity clearly fulfilled the mobile learning potential (e.g., authentic context, personalized learning experience) better than the three earlier cases.

5.2.8 Reflections on the Third Evaluation Cycle

All four case studies in three evaluation cycles indicated that the mobile application brought a motivating and engaging element to learning. Especially in the Leaf Structure case, the students being able to work with their own material increased their interest and motivation. Thus, the learner aspect was clearly present in the third evaluation cycle. The Leaf Structure case also indicated that the device and application were mainly easy to use. However, the case also indicated that even minor problems reflected on the students' experience. Hence, the Leaf Structure case supported the idea that the device, learner, and social aspects intersect. The Leaf Structure case study indicated that the mobile application encouraged social interactions. However, the social aspect was slightly questionable because the mobile technology was not used to mediate collaboration or social interactions.

Also, the importance of pedagogical practices and the activity design was again highlighted in the Leaf Structure case. This justified the pedagogical aspect being raised to the center in the framework.

Overall, the Leaf Structure case study supported the aspects and interrelationships of the revised framework. However, the contextual factors (i.e., teacher's competencies, ICT integration strategies) that emerged especially in the two earlier evaluation cycles should be investigated in more detail. More evidence is also needed that relates the different aspects and investigates the relationships among them.

5.3 Summary of Design Cycle Two

The aim of design cycle two was to evaluate and advance the initial mobile learning framework developed in design cycle one (subchapter 4.1) and to address how the different aspects and characteristics of mobile learning interrelate. The aim was particularly to discover the core aspects and characteristics of mobile learning and how these aspects interrelate.

The findings relating the core-level aspects and medium-level aspects were similar in all the evaluation cycles and cases. However, all the cases involved the teachers' first time using mobile technologies as a part of their teaching practices and, therefore, similar aspects may have existed. The situation may have been different if the teachers had utilized mobile devices for a longer time. Another shortfall of the case studies was that they were short term. Longer term cases may have resulted in different aspects. For these reasons, more evidence was needed and therefore the third design cycle was required.

The aspects that were fulfilled sufficiently in all four cases were medium-level aspects, including the learner, device, and social aspects. Thus, these can be seen as central aspects of mobile learning. The mobile learning activities were motivating and meaningful to the students and in most cases the mobile application was well suited for students' needs. No major technical problems occurred during the experiments and students agreed that the use of mobile devices and applications was easy. However, the case studies also indicated that even minor technical and usability challenges had an effect on the students' overall learning experience. Therefore, the case studies highlighted the significance of device and application usability. The social aspect was slightly questionable as the mobile technology in most cases was not directly used to mediate interactions or collaboration. Nevertheless, in all cases the mobile application clearly encouraged social interactions either with peers or with adults. Overall, the case studies evoked the idea that the device, learner, and social aspects intersect because the balance of these aspects is important.

The core-level aspects (i.e., context, time, and space) were more challenging. The context in which the mobile devices were used was in most cases interspersed with traditional classroom learning and unfortunately the implementations were not as authentic and spontaneous as they could have been. One of the reasons was that in all the cases the activities needed to be relevant to the school curriculum. Another reason was that the implementations were tied to a strict schedule. In other words, the school curriculum and schedule created some challenges. The case studies also indicated that the teacher and his or her pedagogical practices have an impact on the implementation. Because the cases represented the teachers' first time to implement mobile learning activities, all the potential was not used and therefore all the mobile learning aspects were not fulfilled as expected. The inexperience was reflected, for instance, in attempts to adapt the old pedagogies to mobile learning activity. The case studies also indicated that the mobile application by itself does not guarantee quality or meaningfulness in the learning experience. The pedagogy is equally important. The Leaf Structure case, for instance, indicated that having a clear pedagogical objective and integrating mobile device use meaningfully into other tasks and the learning continuum is important. Therefore, the pedagogy was raised as a central aspect of the framework.

The first three case studies also evoked the idea that the core-level aspects should be characteristics of the mobile learning experience and that they are the result of the mobile learning activity design as well as the mobile learning process. In other words, the teacher's decisions may affect the authenticity and spontaneous aspects. In the teacher interviews, other aspects emerged outside the framework. These were contextual issues such as the teacher's competencies, ICT integration strategies (such as adequate equipment and support), and technological, social, and cultural changes. In the initial mobile learning framework, these factors were included in core-level aspects. However, based on the case studies, they should be investigated in more detail.

Based on the observations made in the evaluation cycles, the mobile learning framework was revised (FIGURE 28; see also Rikala 2014c).

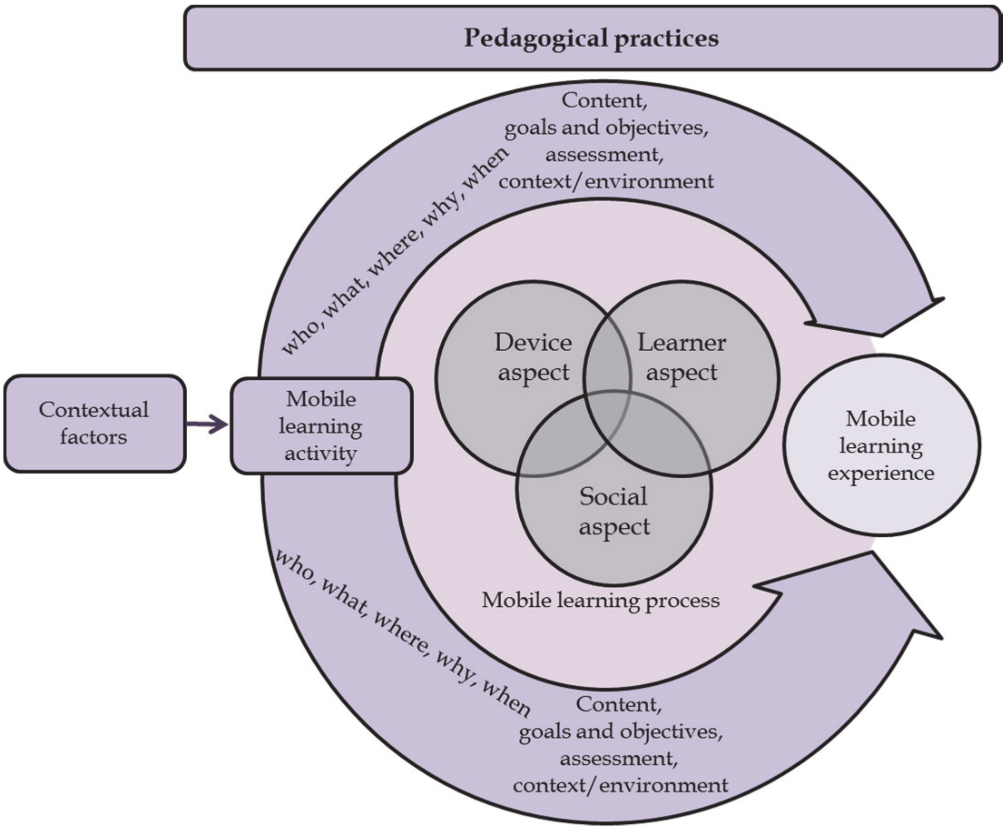

FIGURE 28 Revised version of the mobile learning framework based on the three evaluation cycles

Basically, the four case studies indicated that characteristics such as authenticity and spontaneity, which previously were included in the core level, may actually be a result of the mobile learning activity design and the mobile learning process. The core characteristics of a mobile learning process, in turn, are the learner, device, and social aspects. The interplay of these three aspects is also seen as important. For instance, challenges with device usability may influence the learning experience. Social interaction can promote learning. Thus, in mobile learning, learners can move within physical and virtual locations and participate and interact with each other as well as with information and systems. Therefore, these three aspects intersect. Also, pedagogical practices are seen as important. Pedagogical practices culminate in mobile learning activity design and affect the mobile learning process as well as the mobile learning experience. Also, contextual factors are included in the revised framework; however, as stated earlier, they should be investigated in more detail.

5.4 Further Development Needs Based on Design Cycle Two

After design cycle two, many open questions remained. Would the aspects be the same if the teachers had already utilized mobile devices for a longer time or if the cases had been longer term? Does the new division for pedagogical practices, the mobile learning process, and the mobile learning experience work? What about the contextual factors? How would the factors emerge in different situations and contexts? The third cycle was more than justified for advancing the revised mobile learning framework and highlighting the contextual factors that affect mobile learning in a formal educational context.

6 DESIGN CYCLE THREE: FINALIZING THE MOBILE LEARNING FRAMEWORK BASED ON AN ONLINE SURVEY

Design cycle two triggered design cycle three because it indicated that contextual factors such as core curriculum, ICT integration strategies, and teacher competencies affect mobile learning in a formal educational context and thus should be investigated in more detail. The existing and verified aspects (i.e., learner, device, social aspects) of the developed mobile learning framework would be once again reflected and the role and the place of the challenging core-level aspects would be re-examined. The aim of design cycle three was also to find aspects that were not observed in cycles one or two (Chapters 4 and 5). Thus, the objective of design cycle three was to verify the existing and emerged aspects and to find other important factors that may affect the sustainable and meaningful integration of mobile devices into teaching and learning; in other words, the intent was to answer research questions one, two, and three (subchapter 1.2). The aim of design cycle three was also to explore the ways in which mobile devices have been integrated as a part of teaching and learning. The participating teachers in design cycle two (Chapter 5) were inexperienced and therefore design cycle three focused on experienced teachers who had used mobile devices for a longer time to examine whether the aspects would differ from the design cycle two findings. The hypothesis also was that the experienced teachers' implementations are perhaps longer term. Thus, an online survey was conducted to evaluate and advance the revised mobile learning framework (FIGURE 28, 135) and to find other aspects and factors that affect mobile learning. The online survey and design cycle three will be introduced in more detail in the following subchapters.

6.1 Designing the Online Survey

In design cycle three, an online survey was conducted to gather teachers' views about mobile learning and the ways in which they have used mobile devices as a part of their teaching practices. The aim of design cycle three was to discover missing factors and aspects which did not emerge in design cycle two. An online survey was considered a good method as it can gather information quickly and reach rather a large and varying sample (Sue & Ritter 2007, 9). Thus, the aim was to gather information and examples from a sample of Finnish teachers regarding their mobile learning implementations in their own words and to compare the aspects that emerged in teachers' descriptions to the aspects found in the literature and design cycles one and two (subchapters 3, 4 and 5). Specifically, questions related to descriptions of the teachers' mobile device implementations needed to be open-ended questions.

The reason why the descriptions needed to be in the teachers' own words was that it would give a better overview of what really happens in Finnish educational settings. Also, researcher bias was minimized. Online surveys are especially suitable for situations in which interviewer bias or a tendency toward providing socially desirable answers may threaten the trustworthiness of the data (subchapter 2.3.2).

The online survey in design cycle three was compiled to the Korppi system (https://korppi.jyu.fi), which was developed at the University of Jyväskylä. The system, among other things, enables online surveys for the research and educational purposes of university students and staff. Two Facebook groups[16] were selected as a distribution channel. The link to the Korppi survey was shared in the two Facebook groups with a short foreword. The survey was open for two months (between 3.6.2014 and 3.8.2014). The survey was anonymous.

6.1.1 Participants

Sue and Ritter (2007, 5) argued that online surveys work best in closed populations where the respondents are known to have the necessary Internet access. For this reason, two Facebook groups were selected as a distribution channel. Thus, the sampling method was nonprobability convenience sampling, which means that potential participants self-selected into the sample. According to Sue and Ritter (2007), this kind of sampling has some challenges. First, statistical inference is problematic. Second, respondents who self-select into online surveys are not always representative because they tend to be individuals who have a particular interest in the survey topic. (Sue & Ritter 2007, 32.) However, the two Facebook groups were particularly chosen because the aim was to reach teachers who had already used mobile devices as a part of

16 Facebook groups Tablet Devices in Teaching (in Finnish Tablet-laitteet opetuksessa) and ICT in Education (in Finnish Tieto- ja viestintätekniikka opetuksessa).

their teaching practices. The two Facebook groups addressed issues related to ICT and mobile device usage in the Finnish educational context and it was anticipated that the desired group would be reached. Hence, this kind of nonprobability sample works well for the purpose of the study. The most important characteristic of any sample, according to Sue and Ritter (2007, 35), is that it is representative of the population from which it is drawn. Most members of the two Facebook group were teachers. They were also of different ages and had different levels of ICT skills. In this sense, the two groups represented a varying sample of teachers with adequate representativeness.

The survey respondents' background information was also eventually set against information about the population. Information about the population was obtained inter alia from the Organization for Economic Cooperation and Development (OECD) indicators (2013) and information provided by the Finnish National Board of Education (Opetushallitus 2014). This comparison indicated that the survey respondents were sufficiently representative (see subchapter 6.2.1).

6.1.2 Data Collection and Analysis

The online survey included eight multiple-choice questions and four open-ended questions. TABLE 25 presents the online survey themes. The survey is also attached to APPENDIX 13.

TABLE 25 Online survey themes

The Online Survey Themes
1. Background information
2. Mobile device utilization
3. Teacher's competencies
4. Mobile learning activity
5. Other perspectives

The data analysis for the open-ended questions in design cycle three was conducted through the developed mobile learning framework which was revised in design cycle two (see Chapter 5). However, when categorizing teachers' mobile device usage, the frameworks introduced by Puentedura (2009) and Norrena, Kankaanranta, and Nieminen (2011) were also exploited. Both of these frameworks are introduced in subchapter 3.5, which describes the factors that affect mobile technology integration. Also, inductive category development was employed when categorizing open-ended answers. APPENDIX 17 describes the analysis frame in more detail.

Although the statistical inference is problematic in nonprobability sampling, a cross-tabling and a chi-squared test were used to see whether there were differences between the expected frequencies and the observed frequencies (e.g., checking the impact of age, gender, and place of residence against frequency of use of a mobile device). The number of units in some subgroups, however, was so low that it prevented qualified generalizations from being made. Therefore, statistical inference is excluded from this thesis. Thus, the quantitative data are only used to illustrate the online survey respondents' background information.

6.2 The Evaluation and Revision Cycle

As noted earlier, the aim of design cycle three was to evaluate and further develop the mobile learning framework (FIGURE 28, 135) which was reconstructed in design cycle two (Chapter 5). The aim was particularly to verify the existing aspects as well as find other aspects that may affect mobile learning integration in a formal educational context. The objective was also to explore the ways in which mobile devices have been integrated as part of teaching and learning. The data analysis was conducted mainly through the developed mobile learning framework. The following subchapters will discuss the evaluation and revision cycle and highlight how the different aspects emerged in the online survey, the development needs that arose during the evaluation phase, and how the framework was revised.

6.2.1 Evaluating the Mobile Learning Framework

This subchapter discusses the evaluation of the developed mobile learning framework. It begins with a short description of the online survey respondents' background information and the rest of the description follows the survey themes (i.e., mobile device utilization, competencies, activity, and other perspectives). Also, the link to the revised mobile learning framework (FIGURE 28, 135) is highlighted.

Respondents' Background Information

The respondents' background information was surveyed using five questions related to gender, age, domicile, teaching subject/level, and teaching years. A total of 77 teachers answered the online survey. The exact response rate is difficult to calculate. The two Facebook groups where the online survey was distributed have 16,274 members.[17] However, some of the members are members of both groups and the groups also include many non-teachers as members (e.g., researchers, consultants). Hence, the exact response rate is unknown.

The respondents' background information is shown in TABLE 26. A majority of the respondents was female (68%). However, it was encouraging to notice that the survey also had about 32% male respondents. This big difference between the response rates is not surprising because the field of education and teaching in Finland on the whole is rather female-dominated (Lassila & Teivainen 2014). The OECD indicators, for instance, pointed out that the

[17] Status at 24.9.2014.

percentages of Finnish female and male teachers were 71% and 29%, respectively, in 2011. Actually, teaching is a female-dominated profession in all OECD countries where on average two-thirds of the teachers and academic staff are women (OECD 2013).

TABLE 26 Respondents' background information

Respondents' Background Information		
Gender (n=77)	Female	68%
	Male	32%
Age (n=77)	< 30 years	8%
	30-39 years	32%
	40-49 years	38%
	50-59 years	17%
	> 60 years	5%
Domicile (n=77)	Southern Finland	45%
	Province of Eastern Finland	8%
	Western Finland	34%
	Province of Oulu	9%
	Province of Lapland	4%
Level of education (n=74; three missing answers)	Primary education	24%
	Secondary or upper secondary education	62%
	Vocational or higher level education	14%
Teaching years (n=76; one missing answer)	Less than one year	1%
	Less than 5 years	22%
	6-10 years	22%
	11-20 years	32%
	More than 20 years	21%

Also, respondents from all age groups were reached. The vast majority (70%) of the respondents was 30-49 years of age. The age range compared with the age distribution of Finnish teachers by OECD indicators is relatively similar (FIGURE 29). However, in the OECD indicators, the representation of 50-59 years of age is greater and the representation of 30-39 and 40-49 years of age is smaller (OECD 2013) than for the survey respondents.

The respondents also came from different parts of Finland. The majority of the respondents (79%) was from southern and western Finland. Respondents from Åland were missing, but this was anticipated because the survey was in Finnish and Åland is a Swedish-speaking region. The survey respondents' home county compared with the information about teachers' provinces provided by the Finnish National Board of Education (see Opetushallitus 2014) in 2014 is somewhat similar (FIGURE 30, 143).

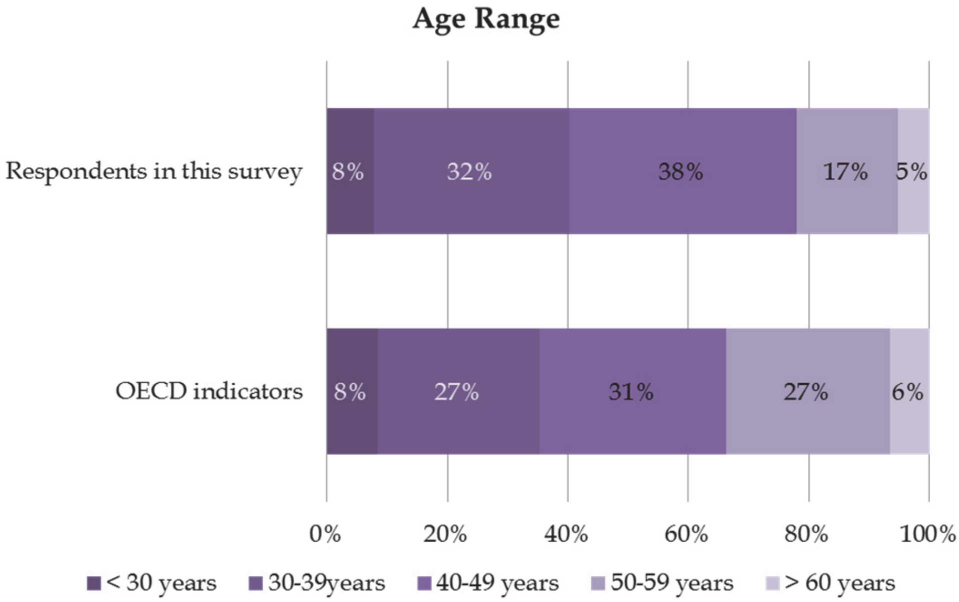

FIGURE 29 Age range of the survey respondents (n=77) compared to the age distribution of Finnish teachers by OECD (2013) indicators

Also, almost all the different teaching subjects/levels were covered; 62% of the respondents was subject teachers in secondary or upper secondary school, 24% was elementary school teachers, and 14% was vocational or higher education teachers. Also, 24% of the subject teachers in secondary or upper secondary school taught mathematical subjects (e.g., mathematics, physics, chemistry, or ICT), 20% languages, 17% the mother tongue, 11% biology and geography, 9% religion, philosophy, psychology, and ethics, and 9% remedial education. In addition, physical and health education (4%), art (4%), and history (2%) were mentioned. When asked about respondents' teaching years, 75% of the respondents stated that they have taught more than six years and 23% have taught less than six years.

Thus, the background information of the respondents indicated that overall the survey reached a rather varying sample of Finnish teachers who have used mobile devices as a part of their teaching practices. Hence, the survey can provide a rather explicit picture of the current situation of mobile device use in the Finnish educational context.

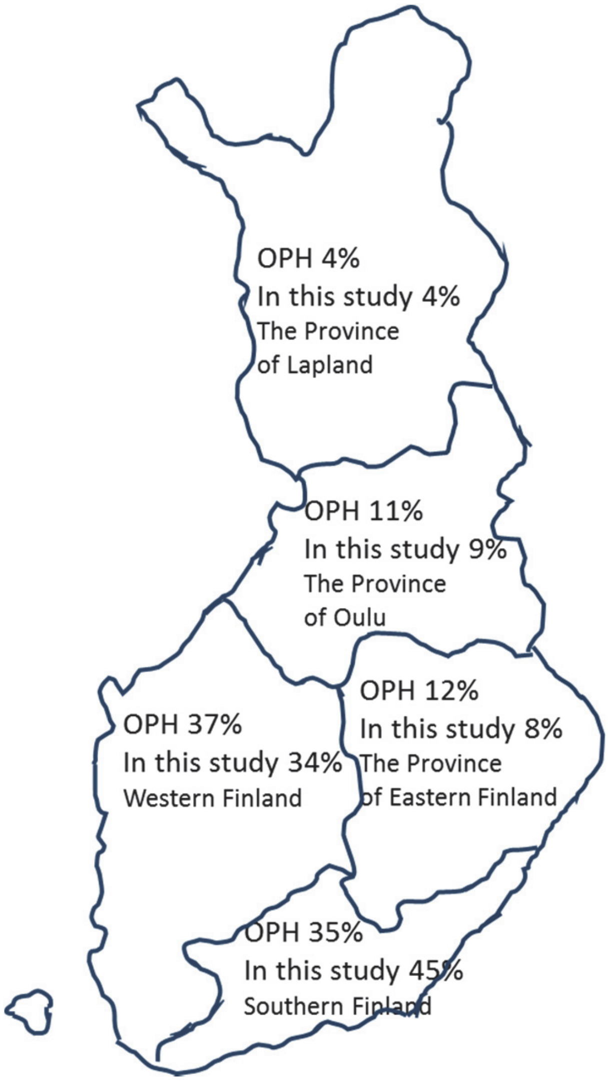

FIGURE 30 Provinces of the survey respondents (n=77) compared with the teachers' provinces from the Finnish National Board of Education 2014 indicators (Opetushallitus (OPH) 2014)

Mobile Device Utilization

This paragraph will describe how often the survey respondents have utilized mobile devices as a part of their teaching practices as well as the reasons why they began to use a mobile device in the first place. These two aspects were surveyed using two questions: How often have you utilized a mobile device as part of your teaching practices, and why did you begin to utilize mobile devices as part of your teaching practices?

A majority of the respondents (83%) has utilized mobile devices on a daily or weekly basis (TABLE 27). The survey evidently reached teachers who already had used mobile devices as a part of their teaching practices as none of the respondents agreed with the statement: *I have not used mobile devices as a part of my teaching practices*. Only two respondents said that they used mobile devices less frequently.

TABLE 27 Mobile device utilization

Mobile Device Utilization		
How often have you utilized a mobile device as part of your teaching practices? (n=77)	Daily	32%
	Weekly	51%
	Monthly	14%
	Less frequently	3%
	I have not used	0%

In other words, the survey clearly indicates that mobile devices are being used more and more in the Finnish educational context, not just as a one-off or occasional activity, but on a weekly or even daily basis (TABLE 27).

The survey respondents' reasons for taking advantage of mobile devices varied (n=71; six missing answers). However, some main trends were apparent. The most commonly mentioned reason for beginning to use mobile devices as a part of teaching practices was to enhance, facilitate, or diversify work (30 mentions). The second most common reason was participation in the ongoing project or that the school had made equipment purchases (19 mentions). The third most common reason was a teacher's own interest and willingness to transform his or her teaching practices (18 mentions). The fourth distinctive theme was the spirit of the times (14 mentions).

Technological changes inevitably influence teaching and learning. For instance, the teachers argued that mobile devices are a solid part of students' everyday lives and that they offer a natural way for students to learn. Future skills were also mentioned and the fact that schools should provide students with the skills that are needed and used in real life. Other less frequently mentioned arguments included to improve learners' motivation and facilitate active learning, the demand to utilize students' devices, the shortage of other devices, and the inspiration prompted by training or others' examples. TABLE 28 lists some of the teachers' survey comments (quotations have been selected randomly). Overall, the survey indicated that the reasons for mobile device integration can be divided into two main driving forces. First, teachers' interest and aim to enhance or develop their own teaching practices is one driving force; second is pressure to change (e.g., schools have made equipment purchases, students already have access to devices, teachers need to teach skills that students will need in the future).

TABLE 28 Descriptions of why teachers decide to take advantage of mobile devices

Reasons why Teachers Decided to Take Advantage of Mobile Devices	
To enhance, facilitate, or diversify work	I thought it would help me to improve my work as well as to reduce the workload at some point. (Respondent 18) Ease of implementation, suitability for students, versatility, and time saving compared to laptops. (Respondent 54)
Ongoing project or equipment purchases	The ongoing project offered the opportunity to receive the equipment. (Respondent 9) We got iPads in our school. (Respondent 28)
Teacher's own interest or willingness to change teaching practices	I wanted to make my teaching more attractive to my students. (Respondent 1) I always like to test new systems and applications to see if they are suitable for my own teaching. (Respondent 27)
Spirit of the times	It is important to teach students today's learning with today's devices. (Respondent 53) Mobile devices are present day. (Respondent 76)
To motivate learners	I have utilized mobile devices because they can motivate a large part of the students and perhaps because of that they even learn something at the same time. (Respondent 21) Mobile devices can bring variation and the students remain interested. (Respondent 23)
Bring Your Own Device (BYOD)	I wanted to use smartphones in teaching, because students would use them anyway. (Respondent 2) Students already have their own equipment with them. (Respondent 61)
Lack of other equipment	There are not enough computers for everyone in our classroom and those are not high-speed either. (Respondent 14) Tablet devices are flexible and can be brought to the classroom. Computers in our school are only in the computer lab and it is often occupied. (Respondent 34)
Inspired by the training or others' experiences	I started to utilize mobile devices because I heard some experiences as well as research results. (Respondent 52)

Teacher's Competencies

The teachers' views about their own competencies were surveyed by using three questions: Are you willing to use ICT as a part of your teaching practices? Do you think that you have sufficient ICT skills? Do you think that mobile device integration in a classroom is easy?

Almost all (97%) of the respondents argued that they are willing to use ICT as a part of their teaching practices; 81% said they have sufficient skills to integrate mobile devices into teaching and learning practices. Only 27% (n=75; two missing answers) of all the respondents stated that mobile device integration in the classroom has been difficult. Thus, teachers' view about their own competencies was rather positive (TABLE 29).

TABLE 29 Teachers' competencies

Teacher's competencies		
Are you willing to use ICT as a part of your teaching practices? (n=77)	Yes	97%
	No	3%
Do you think you have sufficient ICT skills? (n=76; one missing answer)	Yes	81%
	No	18%
Do you think that mobile device integration in a classroom is easy? (n=75; two missing answers)	Yes	70%
	No	27%

Reasons why mobile device integration is experienced as easy or hard

The reasons that supported or challenged mobile device integration were similar but, of course, different (n=63; 14 missing answers). The challenges or barriers mentioned were teacher's competencies (11 mentions), ICT integration strategies (9 mentions), learning theories or curriculum (2 mentions), and student competencies (2 mentions). Some of the respondents argued that they do not have the necessary know-how or skills to integrate mobile devices as a part of their teaching practices. Other common arguments were that there is not enough equipment or that the school network is not up-to-date. In some cases, there were also challenges to find appropriate ways to utilize mobile devices in certain subjects. Another challenge was that not all the students had sufficient skills to use the equipment.

TABLE 30 compiles some of the survey respondents' answers relating to the challenges and barriers (quotations were selected randomly).

TABLE 30 The challenges and barriers of mobile device integration

The Challenges and Barriers of Mobile Device Integration	
Teacher's competencies/teacher's beliefs	My ICT skills are poor. (Respondent 14) The production of materials is time-consuming. Learning new things is mentally hard. (Respondent 33)
ICT integration strategies	The school culture is kind of anti-technology and there is no mobile learning present. It is also assumed that teachers will come up with new methods if they just try. (Respondent 5) The technical problems hinder the use. For example, the school has too narrow a network and old equipment. (Respondent 19) The lack of equipment. (Respondent 52)
Learning theories/curriculum	In mathematics, in particular, the use of equipment is unlikely to achieve any added value. (Respondent 24) The old methods must be equal to the new ones. There are not so many ways to utilize mobile devices in my subject. (Respondent 71)
Students' competencies	Students' ability to use the equipment varies a lot. (Respondent 68) Not all the students have their own equipment or the capabilities. (Respondent 71)

According to the survey respondents, factors that supported mobile device integration were the teacher's competencies (20 mentions), easy-to-use devices and diverse applications (12 mentions), students' competencies (3 mentions), ICT integration strategies (3 mentions), support of peers (2 mentions), training (1 mention), and learning theories or curriculum (1 mention). The teachers' own interest and willingness to train and experiment was mentioned as a significant factor in the success of mobile device integration. Another important factor was device usability. Mobile devices were perceived as easy to use. Also, students' willingness to use mobile devices, peer support, and sufficient training were considered necessary. One respondent also argued that mobile devices are an essential part of his teaching subject and curriculum and therefore it was easy to integrate mobile devices into teaching. TABLE 31 represents some of the survey respondents' answers related to factors that support the implementation of mobile learning (quotations have been selected randomly).

TABLE 31 Teachers' descriptions of the supporting factors of mobile device integration

Factors that Support Mobile Device Integration	
Teacher's competencies/teacher's beliefs	The own interest guides the practices. Of course, there have been some challenges, but as a whole the integration has been easy. (Respondent 3) My enthusiasm and interest have helped me acquire skills in how to utilize mobile devices. (Respondent 29) It only requires the right attitude and some courage. (Respondent 59)
Easy to use devices and applications	They are easy to use and portable. (Respondent 1) Ease of use. (Respondent 43)
Students' competencies	Students consider mobile devices as a natural part of teaching. (Respondent 28) Students have been excited to take familiar equipment as a part of learning. (Respondent 32)
ICT integration strategies	The school provides good resources. (Respondent 30) We got iPads in our school. (Respondent 41)
Peer support	Students give some hints on how to use equipment; ideas from colleagues. (Respondent 4) Cooperation with colleagues and good advice from others. (Respondent 47)
Training	I have received relevant training. (Respondent 61)
Learning theories/curriculum	Devices are an essential part of the graphic design curriculum. (Respondent 62)

Mobile Learning Activity

The respondents were also asked to describe mobile learning activity that they had implemented. A total of 66 teachers described their activity, some broadly and some briefly. First, the nature of the mobile learning activity was analyzed. Five main trends were found. Note that some of the activities also included several characteristics. In most cases, the mobile devices were used when creating content like music, videos, animations, games, or books (28 mentions). It was also common to use mobile devices for enhancement (13 mentions). Puentedura (2009) classified ICT usage levels as enhancement and transformation (see subchapter 3.5). In the survey data, the enhancement level particularly means writing notes, searching information, sharing materials, returning home-work, and using the device instead of a booklet or handout. Another common way to utilize mobile devices was in drill and feedback activities (12 mentions), such as using games or multiple choice tests/quizzes to present learning materials, obtain responses from learners, and provide feedback. Mobile devices were also used to document the progress of the work or reflect one's own learning in blogs and learning diaries (8 mentions). Note that there were surprisingly few cases (8 mentions) in which the learning was extended outside the classroom although mobile technology can extend the learning environment meaningfully into authentic contexts (Chapter 3). TABLE 32 comprises some of the teachers' survey comments about the nature of the mobile learning activity (quotations have been selected randomly).

TABLE 32 Teachers' descriptions of the nature of the mobile learning activity

The Nature of Mobile Learning Activity	
Content production	I gave a task to my class to write and compose Christmas season rap music with a Garage Band application. (Respondent 8) We created a game with the Stick Around application about whales (e.g., identification of whales and opening the concepts of baleen whale and toothed whale). (Respondent 29) The task was to create an educational video as a part of course works. (Respondent 32)
Enhancement	The aim was to use the mobile device and electronic learning environment instead of an exercise book. (Respondent 19) The Showbie application has replaced handouts. Students make a task and return it as a pdf file to the Showbie. (Respondent 49) We have used devices for information retrieval, writing assignments, videotaping, sharing notes, taking photographs, using various applications for different purposes. (Respondent 67)

(continues)

TABLE 32 (continues)

The Nature of the Mobile Learning Activity	
Drill-and-feedback activities	I made a couple of drill and feedback activities with Socrative application to test students' trigonometry skills. (Respondent 5) Mainly training and testing learning (e.g., Quizlet, Edmodo, and Socrative). (Respondent 20)
Blogs and learning diaries	Students have kept a learning journal in a blog and, for example, written a report about installation exercises either with mobile phones or tablet devices by using photos and texts. (Respondent 35) Students have made documentation of their own learning with their mobile devices. (Respondent 61)
Extending learning outside the classroom	We gathered a digital herbarium. Students were photographing the plants outdoors and if they had time they also used the internet to identify the plants. Eventually the herbarium was put together, for example, with the Padlet, Keynote, or iMovie application. The students could choose the form of their own output. For example, some of the students executed the herbarium in a more traditional way but used the Internet to identify the plants. (Respondent 11) I implemented a project about building styles. Students photographed buildings in the surrounding area, collected data, and finally presented their findings in the classroom. (Respondent 60)

Norrena, Kankaanranta, and Nieminen (2011) divided the use of ICT into basic use and higher level use (see subchapter 3.5). In this regard, most of the mobile learning activities (approximately 60%) described by the respondents were higher level use and less (approximately 40%) were basic level use. This is a very promising observation. Thus, the survey indicates that the teachers have found more ways to utilize the pedagogical potential of mobile devices. However, all the potential of mobile devices is still not utilized; the learning is rarely extended outside the classroom and the spontaneous rarely emerges.

When trying to track why all the potential is not utilized as assumed, the following reasons were observed: (1) time constraints, (2) lack of a Wi-Fi network, (3) user accounts, (4) applications, and (5) enhancement level use. First, education in Finland is more or less scheduled on a semester, daily, and hourly basis (Chapter 1). These strict schedules may pose challenges, especially if the implementation is seeking to build according to the schedule. One respondent, for instance, stated:

> Time ran out. Whenever you are creating something more functional, more time is needed. (Respondent 22)

Another respondent remarked:

> We worked in groups and did themed vocabulary with iPads for two lessons (2x75 minutes). I was intended to do a test with Socrative, but I did not have enough time. (Respondent 47)

Especially, the second statement highlights the endeavor to build the mobile learning activity to fit the strict schedule. The time constraint may lead to the situation of time running out or activities being otherwise limited. Broader projects (e.g., project about building styles or collecting digital herbarium) appear to provide more productive settings and opportunities to extend learning outside the classroom. Therefore, the survey indicated that mobile learning clearly requires cooperation across subject boundaries as well as longer term implementations.

Second, the lack of a Wi-Fi network can cause challenges. When the activity is built so that a network connection is essential, the lack of a network can prevent the whole implementation. For instance, extending learning outside the classroom may not be possible. Problems with the network can also hinder the implementation substantially. One respondent, for instance, reflected:

> The school's network slowed down the process. (Respondent 39)

This network issue is partly related to ICT integration strategies such as equipment purchase and ICT infrastructures. However, it is also related to activity design. Mobile devices have multiple features that can be used without network connections (e.g., a camera, a notepad). Even these features can offer a lot of opportunities and should be considered in an activity planning phase.

Third, some of the applications need sign-up and the terms of use may sometimes be very colorful (e.g., age limits). The teachers, for instance, need to consider whether to create a user identification for a whole class or user identification for every student. Thus, creating a mobile learning environment sometimes is challenging, especially if it consists of a variety of applications and services. One respondent stated:

> The challenge has been to construct a learning wall, to send a link to the wall to students, and eventually even the opening of the e-mail link and the learning wall. (Respondent 68)

The challenges in creating a mobile learning environment may lead to situations in which the devices are employed only for enhancement-level usage where a computer, booklet, or handout is replaced with a ready-made application.

Fourth, the teachers particularly appear to search for ready-made applications which are easy to integrate into teaching and learning and which are somehow linked to the curriculum. The range of applications is enormous and finding suitable applications can be challenging. One of the respondents, for instance, reflected:

> There is a huge number of applications and to find suitable ones has taken time and been nerve-wracking. (Respondent 18)

Another respondent argued:

> It is very important that the devices are a solid part of the learning process. It cannot be based on a dozen different applications. It should be based on a few applications which focus on learning, not teaching. (Respondent 36)

As stated in subchapter 3.3.1, many technological learning systems still rely on a behaviorism approach. Therefore, many ready-made applications may undetectably lead to a behaviorist paradigm (e.g., drill and feedback activities). Another reason which is also linked to application utilization is that the mobile devices are mainly used for enhancement. A computer, booklet, or handout is simply replaced with a mobile device and applications. This kind of usage does not transform classroom practices; neither is all the potential of mobile devices exploited. Therefore, mobile learning activity should be more than just the use of applications. It should extend learning beyond teacher-centered teaching and become part of the learning continuum (subchapter 3). An apt remark from one of the respondents, for instance, was that:

> Mobile devices should be part of the wider socio-technical unity. (Respondent 69)

Thus, the significance of pedagogical practices and activity design is once again highlighted. Using mobile technology for mobile technology's sake is not an appropriate way to integrate mobile technologies for teaching and learning as highlighted in the literature (subchapter 3.5). Other important aspects (i.e., learner aspect, and social interactions) of the mobile learning process should also be considered. This naturally leads to the question: How are the aspects of the revised mobile learning framework (FIGURE 28, 135) present in the survey respondents' mobile learning activity descriptions?

All the mobile learning framework aspects and factors were found. However, some of the aspects were less visible than others. For instance, teacher competencies were not reflected or mentioned as directly as in the previous question about mobile device integration.

Many of the survey respondents said that they utilize mobile devices to promote cooperation and interactions. Various group work and interactions with peers and the teacher were mentioned. These observations can, of course, be combined with the social aspect (23 mentions).

The use of mobiles was often justified because it can motivate learners. In mobile learning activities, the teachers also appeared to give more freedom of choice to learners. According to the teachers, differentiation and personalization of the activities are also easier with mobile devices and mobile learning can serve different types of learners, even pupils who receive remedial or special-needs education. All these observations are related to the learner aspect (21 mentions).

The device aspect (8 mentions) was mainly present only when technical problems had occurred, such as challenges with the battery charge or problems with data connections. The device aspect is also closely related to ICT integration strategies, which were mentioned several times. For instance, the respondents criticized the school network as well as the lack of mobile devices. The other contextual factors were not strongly present in the respondents' answers. For instance, learning theories and the curriculum were mentioned only five times. Some of the respondents stated that they choose a specific textbook chapter for a learning activity. Only two respondents clearly mentioned the curriculum. The teacher's competencies (5 mentions) were not directly mentioned. However, the respondents were, for example, reflecting the teacher's new role and positive experiences. The negative arguments were related to difficulty in finding meaningful ways to use mobile technology in certain subjects and a general negative attitude toward mobile learning. Some of the teachers also described their pedagogical choices (e.g., a flipped classroom, collaborative working). However, pedagogy was not strongly present in respondents' answers. TABLE 33 comprises quotations related to aspects of the mobile learning framework (quotations have been selected randomly).

TABLE 33 Mobile learning framework aspects emerged from the survey respondents' mobile learning activity descriptions

The Mobile Learning Framework Aspects	
Social aspect	We have played the Kahoot game every week. The aim has been to motivate and activate students as well as to promote the ability to cooperate. The students worked together and got activity points. The cooperation went right. Especially boys were motivated. The game improved a sense of solidarity and brightened the double-hour class. (Respondent 16) Students used a chat to interact and cooperate with each other to complete, for example, group work. (Respondent 18)

(continues)

TABLE 33 (continues)

The Mobile Learning Framework Aspects	
Learner aspect	Students could choose a topic (one of the Asian countries or regions). In addition, students could also choose an execution method (e.g., Keynote/PowerPoint presentation, iMovie tourism video, traditional paper poster). (Respondent 1) I have used the Kahoot game with 7th and 9th grade students. Students seemed to like the game and they really were riveted by the game and wanted to play it again and again. (Respondent 2) Perhaps the best aspect of mobile learning is that completely different students may benefit from it and students that otherwise would not shine at school may shine. (Respondent 55)
Device aspect	Only challenges were that in some mobile phones the video sharing was problematic and in some phones the quality of sound was bad. (Respondent 6) The problems related to challenges to sign in to the school network with the tablet device. Also, the lack of Java and Flash has caused some challenges. (Respondent 13)
ICT integration strategies	There is not sufficient support. (Respondent 5) The challenge was that the school does not have mobile devices and we had to use students' own mobile phones. (Respondent 60) The challenge of the implementation was that the network in our school is inadequate, especially at the east side where my class is located. (Respondent 72)
Learning theories and curriculum	The students made a group work with Book Creator of some of the European countries represented in the textbook. (Respondent 34) We have designed explicit tasks of the key contents of the curriculum. (Respondent 36)

(continues)

TABLE 33 (continues)

The Mobile Learning Framework Aspects	
Teacher's competencies/beliefs	The teacher's role has been to tutor and give some tips on how to improve the outcome. (Respondent 1) The experience of the experiment was positive and I utilize the game in appropriate situations and design new games with different themes. (Respondent 2) I think that the technology was kind of glued on the top and therefore it did not enable new ways of learning. (Respondent 5) The only barrier is the decision-makers', parents', and some teachers' attitudes. (Respondent 52)

Other Perspectives

The last question in the survey included the opportunity for respondents to describe their opinions and views about mobile learning more freely and, therefore, it was the most fruitful question on the survey. A total of 58 teachers described their mobile learning perspectives. Their answers were analyzed through the aspects of the revised mobile learning framework (FIGURE 28, 135).

ICT integration strategies (21 mentions), teacher's competencies (19 mentions), pedagogical practices or simply pedagogy (16 mentions), and change or spirit of the times (12 mentions) were the aspects most often mentioned in the discussion among the survey respondents.

When discussing ICT integration strategies, many of the respondents acknowledged the need for more devices. One-to-one or Bring Your Own Device (BYOD) strategies were considered good ways to respond to the device requirement. Some of the respondents also argued the need for rules that limit mobile device usage to educational purposes. Also, technological support was considered important. Overall, the respondents said that the purchase and implementation of mobile devices should be more structured and justified, as well as carefully discussed. The mobile device hype is not a good reason to purchase devices. One of the respondents argued:

> First of all, you should figure out what to do with ICT. Now it seems that first you buy a bunch of ICT and after that you try to figure out what to do with it. (Respondent 35)

The teacher's competencies also emerged in the teachers' discussion. Many of the respondents said that teachers need more training, both pedagogical and technological. One of the respondents, for instance, stated:

> Students are very handy with new devices, but teachers still need a lot of support and training, both technological and pedagogical. (Respondent 19)

Also, pedagogy was a key topic of discussion. The respondents highlighted the significance of the aims and objectives of the mobile learning activity as well as the importance of identifying principles for the meaningful integration of mobile device usage in teaching and learning. Some of the respondents also highlighted that mobile devices are not suitable for everything and that versatile teaching methods and tools are still needed. One of the respondents ruminated:

> Mobile devices are here to stay! However, it is important to remember that also the pen and paper are good learning tools. All should be utilized whenever it is possible, even the chalkboard. (Respondent 23)

The respondents also considered that mobile devices would in the long term change school culture and working patterns, even though some resistance exists. The respondents argued that mobile devices are here to stay and therefore it is important to accept them as a part of teaching and learning. One respondent stated:

> Mobile devices are multi-functional devices. Those should be involved in school so that children will not think that school is an old-fashioned and dull place. (Respondent 41)

The learner aspect (6 mentions), device aspect (5 mentions), and social aspect (1 mention) were not reflected as frequently as in the mobile learning activity descriptions. The learner motivation and versatile ways of studying and learning emerged a few times in the teachers' discussion. Also the learner's competencies were considered important and the teachers mentioned that not all learners have sufficient skills or interest to use mobile devices. Therefore, defining the learners' needs and preferences is essential. The mobile devices were all in all considered easy to use. However, some problems arose, such as user identification. One of the respondents also argued that mobile devices can create a feeling of solidarity and promote cooperation.

6.2.2 Reflections on the Evaluation Cycle

The online survey highlighted that the important aspects of a mobile learning process are the learner, device, and social aspects. These aspects were present especially when the teachers reflected on their mobile learning activities. The survey respondents stated that mobile devices can enhance and diversify a learning process in many ways and at their best can motivate and activate students. The mobile devices also provide new avenues for interaction and collaboration. Overall, mobile devices were perceived as easy to use and useful in an educational context. Thus, the online survey indicated that the learner, device, and social aspects are core aspects of a mobile learning process and should be kept in the framework.

Based on the survey respondents' arguments, other important aspects that affect mobile device utilization in an educational context are ICT integration strategies and teacher competencies. The survey especially indicated that teacher competencies and ICT integration strategies can at best support or at worst hinder mobile device usage. The survey also indicated that the curriculum design should get more attention as a good curriculum plan can facilitate the ICT integration. The online survey, for instance, indicated that broader projects that combine different subjects offer more productive settings than single-subject lessons bounded by an hourly schedule. For instance, a project about building styles which combined history and visual arts allowed for extending learning outside the classroom and working with various approaches. Otherwise, in many cases, teaching remained rather traditional as the endeavor was to build the mobile learning activity to fit the strict schedule. The implementations that the teachers described were also short term. Therefore, one clear question is, does mobile technology support long-term implementations or does mobile learning basically involve short-term spontaneous actions and interactions? Overall, the online survey indicated that ICT integration strategies, core curriculum and teacher competencies should be added to the framework as they can either hinder or support mobile learning integration.

The survey data also indicated that rapid changes, and especially the spread of mobile devices, are the driving forces that push the implementation of mobile devices in the school context. Thus, technological, social, and cultural changes affect the teaching practices and thereby mobile device use in the educational context. Overall, the teachers discovered some of the potential of mobile devices and are utilizing mobile devices more and more in the educational context. However, it is impossible to say how mobile device use in the school context will appear in the future and therefore more research is needed, especially when mobile devices are well established. Hence, change is one distinct aspect that should be added to the framework.

The survey also indicated that pedagogical practices play a key role when designing mobile learning activity. The key questions are: Why are mobile devices used? Is the aim to enhance teaching and learning? Or is the use higher level usage like extending learning outside the classroom to an authentic context? The decisions about the nature of the activity affect the mobile learning process and experience (e.g., interactions, context, spontaneity, authenticity, meaningfulness). The online survey indicated that how teachers use mobile devices does not exploit all the potential of mobile devices or mobile learning. The learning was rarely extended outside the classroom and the spontaneous rarely emerged. Mobile learning activity should be more about the use of mobile applications or the replacement of a booklet with a mobile device. However, on the other hand, it is also important to look at mobile learning from the device perspective again. The aim, of course, should not bind the teaching and learning only to the device or applications. Nevertheless, it is important to observe, find, and analyze the opportunities that different features of mobile devices can bring to teaching and learning and especially how the use of those features can transform teaching and learning toward a more student-centered and innovative direction. Hence, the online survey emphasized the importance of pedagogical practices and activity design and indicated that pedagogical practices are a key aspect of mobile learning and should be kept in the framework.

6.2.3 Revising the Mobile Learning Framework

Actually, the findings of design cycle three were similar to those of design cycle two (Chapter 5). Design cycle three (Chapter 6) confirmed the contextual factors that were observed in design cycle two (Chapter 5), factors such as the teacher's competencies, ICT integration strategies, and curriculum. It also highlighted that pedagogy and pedagogical practices are significant. Design cycle three (Chapter 6) also indicated that in the mobile learning process, important aspects are the learner, device, and different interactions. One more aspect that design cycle three highlighted was change, which clearly is a driving force for mobile learning. Based on the observations made in design cycle three, a revised mobile learning framework is proposed (FIGURE 31, 160).

In summary, technological, societal, and cultural changes influence contextual factors such as core curriculum, ICT infrastructure, and teacher competencies. These contextual factors, in turn, can either support or hinder mobile learning integration and mobile learning activity design (i.e., pedagogical practices). The activity design includes pedagogical and contextual considerations which also pay attention to learner needs and preferences, device usability, and interaction design. These aspects influence meaningful and personalized learning experiences as well as learning outcomes. Hence, the finalized mobile learning framework particularly illustrates the above-described elements (FIGURE 31, 160).

6.3 Summary of Design Cycle Three

Design cycle two (Chapter 5) triggered design cycle three (Chapter 6) as design cycle two indicated that factors such as core curriculum, ICT integration strategies, and teacher competencies should be included in the framework. Thus, the aim of design cycle three was to verify the existing aspects and to discover missing aspects and factors that affect mobile device utilization in the formal educational context. Design cycle three also explored the different ways in which teachers use mobile devices as a part of their teaching practices.

Both design cycles two and three (Chapters 5 and 6) clearly highlighted the significance of pedagogical practices. Therefore, these practices are brought to the very center of the developed framework (FIGURE 31, 160) and are particularly culminated in mobile learning activity and its design. Mobile learning activity design, in turn, determines the learning goals and contents as well as how learners will use mobile technology to interact and to achieve learning goals. Thus, the activity design also includes the mobile learning process aspects (i.e., learner, device, and social aspects) and in a sense a scenario which illustrates how learners interact with systems, peers, experts, and contents to achieve learning goals. Both design cycles two and three (Chapters 5 and 6) particularly highlighted that the balance of these three aspects is important and affects the learning experience, which in turn affects the learning outcomes. Thus, the technology should be easy to use and intuitive. Also, the interaction design should ensure that the right things are learned. The learning also depends greatly on the learner and, therefore, it is important to understand learners' needs and preferences to design meaningful and sufficiently challenging activities. The activity design also influences aspects such as spontaneity, formality, authenticity, and personality, which are elements of the mobile learning experience.

Design cycle three (Chapter 6) also highlighted other contextual aspects and factors that affect the mobile device utilization in a formal educational context: ICT integration strategies, teacher's competencies, and the core curriculum. These can either support or hinder the planning and implementation processes in a formal educational context. Therefore, they are also included in the framework (FIGURE 31, 160).

Also, technological, societal, and cultural changes which were observed especially in design cycle three (Chapter 6) are highlighted in the framework (FIGURE 31, 160). Change is a driving force for mobile learning and it influences contextual factors such as core curriculum, ICT integration strategies, and teacher competencies. Hence, basically, institutions and teachers are trying to keep up with the pace of change.

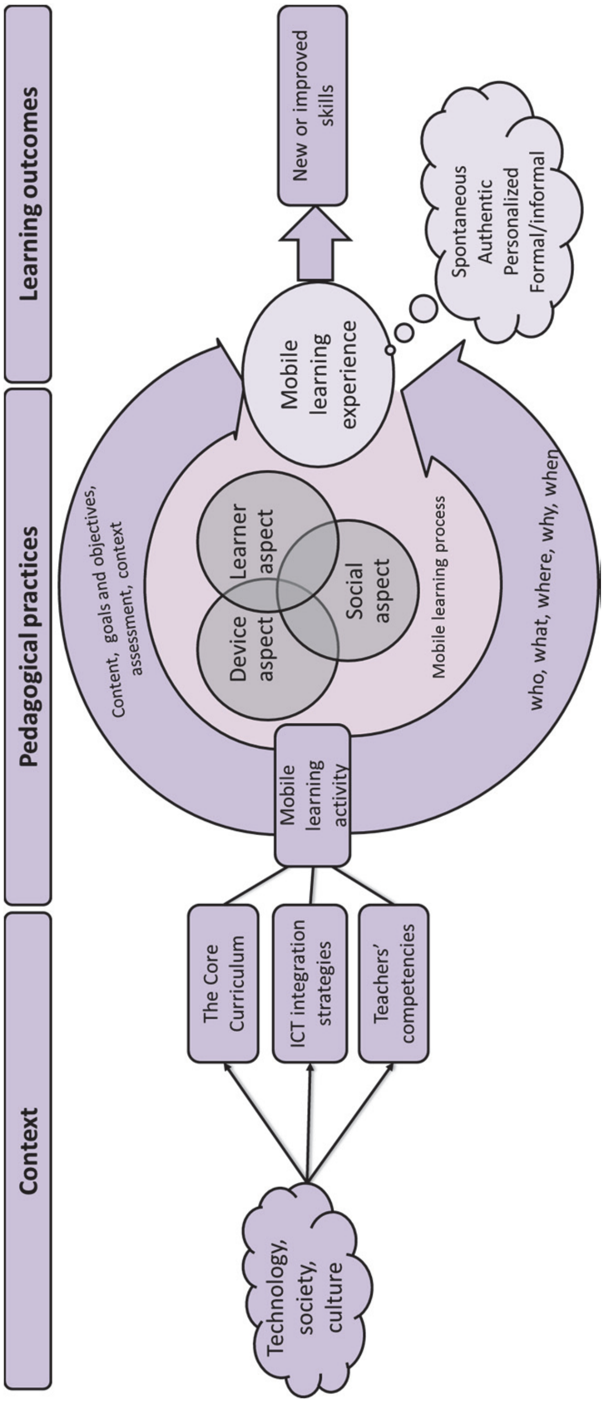

FIGURE 31 Mobile learning framework

6.4 Further Development of the Framework in the Future

Somewhat surprisingly, no need for big changes and new affecting factors was observed during design cycle three (Chapter 6). Based on the observation that the findings were similar to those in design cycles one and two (Chapters 4 and 5), the framework was considered complete and no new design cycles were required. One major challenge in design cycle three, however, was that the mobile learning implementations were short term. This challenge essentially relates to the nature of mobile learning. As the literature has highlighted (Chapter 3), mobile learning is flexible, spontaneous, and thus also rather short term. Therefore, working with mobile devices does not engender perseverance or patience as, for example, with traditional methods or with desktop computers. Mobile learning brings formal learning closer to informal and unintentional learning. Therefore, mobile learning can blend formal and informal learning. However, the ways in which mobile devices are utilized depends on the teacher's planning and practices, and therefore the pedagogy is a key characteristic of the framework.

Even though the teachers' implementations were short term, the case studies and online survey resulted in desired outcomes. The design cycles highlighted the central aspects and factors of mobile learning, the way in which those interrelationships exist, and other contextual factors that may affect meaningful mobile learning integration. Further research and exploration is required to study whether the aspects remain the same over time. Further research would also clarify whether mobile learning is intrinsically short term. It is also important to acknowledge that technology is evolving rapidly and next-generation devices may afford new opportunities and thereby highlight different aspects.

7 DISCUSSION, SUMMARY, AND CONCLUSION

In this chapter, the results of the study will be discussed and summarized, and conclusions will be presented. First, the main findings of the study are discussed in subchapter 7.1, followed by a discussion of the contributions to the field of mobile learning (subchapter 7.2.1). Finally, the trustworthiness of the study (subchapter 7.3) and proposals for further research are stated (subchapter 7.4).

7.1 Answering the Research Questions

This study has addressed mobile learning, specifically mobile learning in a formal Finnish educational context. The study particularly focused on designing a mobile learning framework for a formal educational context and specifically aimed to clarify the factors that affect mobile technology integration in a formal educational context. The research questions were as follows:

1. What are the core aspects and characteristics of mobile learning in a formal educational context?

2. How do the core aspects and factors interrelate?

3. What other important factors affect the pedagogically sensible and sustainable use of mobile technologies in formal educational contexts?

Also, the ways in which teachers are utilizing mobile technologies as a part of their teaching practices were explored. The following subchapters (subchapters 7.1.1, 7.1.2, and 7.1.3) particularly highlight the different aspects and factors and how they interrelate.

7.1.1 The Core Elements and Characteristics of Mobile Learning

The literature (Chapter 4) highlighted that several mobile learning frameworks exist. However, a solid framework is lacking. Therefore, this study aimed to explain the core elements and complex interrelationships of mobile learning to develop a complete mobile learning framework. The study indicated that the key elements and characteristics that affect mobile learning in a formal educational context are **pedagogy, context, learner aspect, device aspect,** and **social interactions**. Many earlier mobile learning studies also identified these elements as central constructs of mobile learning (Chapters 3 and 4).

In this study, the teacher's **pedagogical practices** proved to be especially significant in a formal educational context as these practices culminate in mobile learning activity and its design and, therefore, influence the overall learning experience. Thus, especially in a formal education setting, a teacher's contribution is significant as the teacher plans the situations in which mobile devices are used, the learning goals, and the contents as well as how learners will use devices to achieve the learning goals (subchapter 3.5). Therefore, pedagogical practices have been brought to the very center of the framework and considered important. Also, the case studies and online survey indicated that the pedagogical practices influence the learning activity, learning process, and learning experience (subchapters 5.2 and 6.2). The importance of pedagogical practices is also highlighted in the literature (Chapter 3). Ozdamli and Cavus (2011, 939), for instance, highlighted the role of the teacher and argued that teachers need to be able to identify the students' interests and based on these interests design goals and offer opportunities to reach the goals in specific conditions. This, of course, involves pedagogical practices such as planning the contents, goals and objectives, assessment, and environment (e.g., who, what, when, where, why). In Finland, teachers generally have freedom to choose their teaching methods and materials to achieve the objectives stated in the school curriculum (Chapter 1). Even though teachers have substantial power in decision making, the study indicated that in many cases teachers adapt old pedagogies or simply automate their traditional activities (subchapters 5.2 and 6.2). With traditional methods, it is perhaps easier for a teacher to keep things under control and achieve the goals set. This might be why the mobile learning approaches in this study mainly reproduced old pedagogies with mobile devices. In this study, one significant and noteworthy fact is that the case studies in design cycle two (Chapter 5) were brought to the schedule after the annual planning. The outcome and design of the mobile learning activities might have been notably different if the mobile learning approach had been taken into account in the annual planning process. However, the online survey in design cycle three (Chapter 6) indicated that although the teachers have found some of the potential of mobile devices and are utilizing mobile devices increasingly, the learning was rarely extended outside the classroom and the spontaneous rarely emerged. This highlights the question: Are teachers' teaching practices still relatively traditional and teacher-centered?

Or is this challenge related to mobile learning in education still being a novelty or a seldom used tool in many places? Hence, mobile learning in a Finnish formal education context perhaps has not yet reached the critical mass of experience and practice. Therefore, it is important to continue to research mobile learning practices and especially how those practices are transforming educational practices in the long term.

Nevertheless, the study clearly highlighted that the rethinking of strategies is needed. The aim of mobile learning implementations should be to offer new opportunities for learning that extend learning beyond the traditional teacher-led approach. As the literature has emphasized (subchapter 3.5), the potential lies in using mobile technology with new pedagogy. It is important to remember that the mobile devices themselves do not guarantee mobile learning or meaningful learning experiences. Much depends on the teacher's pedagogical practices and mobile learning activity design. Thus, mobile learning challenges traditional formal teaching and learning and requires more student-centered and innovative practices.

The majority of mobile learning frameworks (Chapter 4) highlight the **context**. In mobile learning, learning can occur in formal and informal as well as physical and virtual settings (Chapter 3). In the revised version of the mobile learning framework, learning is specifically positioned in a formal school context and therefore the framework takes into consideration the contextual factors that may affect the mobile learning. In an informal context or, for example, in corporate settings, the factors that affect the mobile learning vary. The case studies conducted in design cycle two and the online survey in design cycle three indicated that the school culture and school context in general create challenges for mobile learning implementation (subchapters 5.2 and 6.2). Therefore, characteristics such as the core curriculum, ICT integration strategies and teacher competencies are also included in the framework. For instance, in Finland, the national core curriculum influences and directs the education to a certain extent (Chapter 1). ICT integration strategies, in turn, include factors such as technological infrastructure and support, school policy, and opportunities for professional development. The teacher's competencies include technological, pedagogical, and content knowledge, which are highlighted, for example, in the Technological Pedagogical Content Knowledge (TPACK) framework by Koehler and Mishra (2009). The teacher's competencies include inter alia teachers' knowledge about the subject matter to be learned or taught, teachers' knowledge about the processes, practices and methods of teaching (e.g., learning theories), and teachers' knowledge about how to work with technology and apply technological tools and resources in teaching and learning. The teacher's competencies and ICT integration strategies were present in both the case studies and the online survey (subchapters 5.2 and 6.2).

The **learner** aspect is also seen as important because learning depends greatly on the learner him or herself (subchapter 3.5). The learner aspect is highlighted in one way or another in most of the earlier mobile learning frameworks (Chapter 4) and especially features such as personalization, customization, autonomy, and self-regulation are emphasized. Thus, the incentive dimension is significant. Therefore, different learning needs and preferences should be recognized. It is important to acknowledge that individuals learn differently and therefore learning should be personally meaningful as well as sufficiently challenging. The case studies in design cycle two (subchapter 5.2) indicated that mobile learning activities can be motivating and meaningful to students and can bring much wanted variation to the traditional school day. Also, in most of the cases, the mobile application was well suited for students. The Math Trail implementation (subchapter 5.2.1) in design cycle two, for instance, encouraged the students to persevere with the problems, which, in turn, influenced students' test grades. Also, the online survey respondents in design cycle three (subchapter 6.2) highlighted the motivational aspect and the use of mobile devices was justified with the motivating effect. The learners were also given more freedom and choice in mobile learning activities. Hence, learning depends greatly on the learner. Mobile technology may enhance an individual learner's learning process by providing access to the content in multiple formats. Thus, the instruction and actions can be differentiated to reach different learning needs and styles (subchapter 3.5). Therefore, understanding learner needs and preferences is essential and therefore the learner aspect is a key aspect of the mobile learning process and framework.

Also, the **device** aspect is a key aspect and it is highlighted in many earlier mobile learning frameworks (Chapter 4). However, the aim should not be to bind the teaching and learning to the device, but to find ways to transform traditional teacher-centered teaching. In the device aspect, device usability is emphasized. Device usability involves the physical, technical, and functional characteristics of the mobile device. Several challenges exist with mobile devices, such as small screen size, limited processing power, and reduced input capabilities which can affect the learning experience. Therefore, mobile learning systems should be user friendly and intuitive to be suitable and attractive for learners (subchapter 3.5). There were also challenges with the devices in design cycle two's case studies (subchapter 5.2), especially with their reliability. At some point, the students became frustrated and attention was drawn too much to the technology rather than the activity and learning. Thus, the study indicated that even small problems can influence the overall learning experience. The device aspect in the online survey in design cycle three (subchapter 6.2) was mainly present only when technical problems occurred. This highlights the significance of device usability, and therefore the decisions about the device and application functionalities may also influence the mobile learning process and eventually the mobile learning experience and should be considered carefully before implementation. The learner aspect and the device aspect are thus clearly intertwined. Device and application characteristics affect the learner's (similar to the teacher's) comfort, attitudes, and experience. The equipment in the case studies (subchapter 5.2), for instance, was loaned and some students struggled with it. Use of the students' own familiar and safe devices may create a different kind of learning experience for them. Kearney et al. (2012) argued that ownership has implications for the personalization feature. A personalization feature, in turn, includes issues like learner choice, agency, self-regulation, and customization. Therefore, ownership may have implications also for learner motivation, enjoyment, and eventually learning experience.

In this study, **social interactions** are emphasized. Social interactions and collaboration are also highlighted in the literature (Chapters 3 and 4). Different kinds of interactions can stimulate learning. Mobile devices, for instance, have the great potential to support collaborative and conversational learning outside the classroom. In many cases, communication and collaboration, however, play a rather small role. Also, in design cycle two's case studies, the mobile technology was not used to promote social interactions or collaboration (subchapter 5.2). However, the case studies indicated that mobile devices encouraged social interactions with peers and adults. Also, the survey respondents emphasized that mobile technology can promote communication and collaboration (subchapter 6.2.1). Therefore, the decisions about the different interactions and group work are important and should be considered. At best, different kinds of interactions can promote learning.

Thus, in this study, mobile learning is seen as a teaching and learning approach which utilizes mobile devices to extend traditional teaching and learning and to sustain high levels of a student engagement with rich connections to other people and resources across different contexts. Hence, **pedagogy, context, learner aspect, device aspect,** and **social interactions** are perceived as the core elements and characteristics of mobile learning in a formal educational context. Basically, mobile devices can afford many opportunities for learning (Chapter 3). For example, mobile devices enable differentiation and personalization of learning contents and activities based on a learner's needs. This also enables learning across time and space as well as flexible access to information and communication in situ. However, a great deal also depends on the teacher's planning and pedagogy.

7.1.2 The Interplay of the Different Aspects

As outlined earlier, in this study, the learner, device, and social aspects are specifically perceived as the core aspects of the mobile learning process. The study also indicated that the interplay of these three aspects affects the mobile learning process and eventually the mobile learning experience. Thus, the mobile learning process results from the convergence of mobile technologies, human learning capacities, and social interaction (subchapter 4.1). These aspects are consistent with the triangle model introduced by Illeris (2009; see subchapter 3.5). Actually, these three aspects can be comprehended as core aspects of any learning. However, in the different learning approaches the device aspect can be replaced with other tools and resources (e.g., a desktop computer, text-book, pen and paper). In fact, the mobile learning process does not differ from other learning processes. There is always an intent to learn (e.g., knowledge, skills). The learner's internal mental energy is necessary for the learning process to take place (i.e., feelings, emotions, and motivation affect the learning process). The interaction dimension, in turn, provides the necessary impulses that initiate the learning process, for example, design of learning activities, co-operation. (subchapter 3.5.) In mobile learning, the content and activity, however, can be mediated through a mobile device.

When these three aspects (i.e., learner, device, and social aspects) are balanced, the mobile learning process progresses smoothly. The case studies in design cycle two (subchapter 5.2), for instance, indicated that problems with technology may frustrate students, which is reflected in the students' learning experience. The case studies also indicated that the interaction design should receive more attention. Thus, the activity design, and especially the interaction design is important. Basically, the activity design determines what kind of learning process and eventually learning experience evolves. Thus, the mobile learning experience is seen as a result of the mobile learning activity and the mobile learning process. Eventually, a motivating and meaningful mobile learning experience and process can help a learner develop new or improve existing skills.

Contextual factors such as ICT integration strategies, the teacher's competencies, and core curriculum affect the mobile learning activity design. Those can either hinder or support mobile learning integration (subchapter 3.6). Decisions about the learning environment, for instance, can affect the authenticity and spontaneity. In the case studies, the learning situations were not spontaneous, situated, context-aware, or authentic (subchapter 5.2). One of the reasons was that the activities needed to be relevant to the school curriculum and they were scheduled and conducted in the school environment. Thus, the context in which the mobile devices were used was interspersed with traditional classroom learning and the time when the devices were used was specifically designed and fit into the schedule. In the online survey in design cycle three (subchapter 6.2), there were also only a few cases where the learning was extended outside the classroom and school. Also, the mobile learning process aspects, such as learner and device, influence the overall mobile learning experience. Technical problems, for instance, draw too much attention to technology or frustrate students. The study also indicated that mobile learning activities should be personalized so that they attract and serve a wide range of learners (subchapter 5.2). Eventually, a motivating and meaningful mobile learning experience and process can help in developing new or improving existing skills, as indicated in the Math Trail activity (subchapter 5.2). It is also important to acknowledge that a technological, cultural, and societal change has its own impact; it influences, for example, the core curriculum, the ICT integration strategies, and the teacher's competencies and beliefs.

7.1.3 Other Factors that Affect Mobile Learning

The study indicated that in a formal school context the contextual factors such as **core curriculum**, **ICT integration strategies**, and the **teacher's competencies** affect the mobile learning integration by either hindering or supporting the integration process. The study indicated that in a formal school context mobile device use is not as spontaneous or authentic as it could be and it is often bound by the classroom or time constraints (subchapters 5.2 and 6.2). In that sense, the key question is: Can we even talk about mobile learning in the formal educational context? The teachers have expressed interest in integrating mobile devices in their teaching and find them meaningful and useful (subchapters 5.2 and 6.2). However, because mobile learning is still a relatively new method, teachers clearly need support and training. In the case studies (subchapter 5.2), the lack of necessary skills to integrate mobile devices into daily life, for instance, was the main reason why mobile device usage was not extended to authentic contexts and remained mainly for basic use. Teachers need to understand how to integrate mobile technology into the curriculum. Thus, the study indicated that the teacher's competencies and beliefs are crucial aspects of successful mobile device integration and implementation. The teacher's competencies include inter alia teachers' knowledge about the subject matter, methods of teaching, and knowledge of how to integrate technological tools and resources into teaching and learning (subchapter 3.6). Therefore, both technological and pedagogical support should be available, as should opportunities for professional development. Support and training can help teachers find meaningful ways to integrate mobile devices into teaching and learning, overcome technological problems, and develop their skills and transform their practices. Teachers also clearly need examples of classroom practice; such examples can inspire ideas for how to transform teaching practices, as indicated in the Literature Tree case (subchapter 5.2.1). Transformation of teaching practices and mobile learning integration require resources and tools.

The study also indicated that ICT integration strategies can either hinder or support mobile device integration (subchapters 5.2 and 6.2). ICT integration strategies include, among other things, school leadership, support, and ICT infrastructure (subchapter 3.6). If the school culture and vision are anti-technology and no mobile devices are available or the infrastructure (e.g., school network) does not support mobile device usage, teachers' opportunities to integrate mobile technologies into teaching and learning are insufficient. Therefore, mobile learning can be promoted with adequate technological infrastructure. School leaders should actively promote mobile technology and ICT use by ensuring budget and funding as well as technological infrastructure (subchapter 3.6). Also, the school leaders should not overlook the adequate support and opportunities for professional development. This was highlighted especially in the Nature Tour case (subchapter 5.2.4).

Also, a curriculum design can facilitate the integration process (subchapter 3.6). The online survey in design cycle three (subchapter 6.2) indicated that broader projects combining different subjects offer teachers more productive settings in which to design and implement a mobile learning approach than single-subject lessons bound by an hourly schedule. Because the core curriculum directs the education at certain level (Chapter 1), the curriculum should provide necessary structure and procedures for how to integrate technology into teaching and learning more seamlessly and pervasively. The core curriculum together with technological infrastructure and professional development can also influence the teacher's beliefs and practices (subchapter 3.6). The teachers in the Nature Tour case study, for instance, stated that they have plenty of other activities and materials to go through during the preschool year and therefore the integration appeared extremely difficult (subchapter 5.2.4). This curriculum pressure, coupled with insufficient skills, inadequate support, and insufficient resources to practice, also reduced the teachers' enthusiasm and willingness to adopt a mobile learning approach. This kind of pressure (e.g., lots of materials, goals, strict schedules, insufficient competencies) may also create a barrier which steers teachers toward traditional teacher-led practices. Also, the online survey respondents highlighted the need for adequate resources, competencies, and support (subchapter 6.2). Thus, the study highlighted the significance of curriculum design, ICT integration strategies, and opportunities for professional development.

The Finnish National Board of Education will introduce a new core curriculum in the autumn of 2016 (Opetushallitus 2015). The new core curriculum emphasizes phenomenon-based learner-centered learning and technology integration. This new curriculum may also provide more fruitful terms of reference for mobile learning. On the other hand, in Finland, a teacher is legally responsible for the safety of students during the school day as well as responsible for organizing a safe environment for the students (Opetusministeriö 2000; Poutala 2010; Suopohja & Liusvaara 2000). This is not always possible when learning is extended outside the school and, therefore, some teachers may forsake teaching and learning outside the classroom for safety and liability reasons. In addition, in some municipalities, teaching and learning outside the classroom must be included in the annual plan. Therefore, extending teaching and learning spontaneously outside the classroom is not always possible. Thus, this may restrict truly mobile learning.

The case studies (subchapter 5.2) especially indicated that mobile learning activities can be motivating and meaningful to students and can bring much wanted variation to the traditional school day. Finland has had a rather low ranking in the international comparisons of students' enjoyment of school (see Harinen & Halme 2012). Additionally, if banning mobile device usage, the school is in a sense drawing back from the students' world. Thus mobile learning integration may bring the school closer to the students' everyday life and result in a positive emotional climate. However, it is important to set guidelines for ensuring the appropriate mobile device usage in an educational context.

One more challenge and question relates to the responsibility for equipment, especially if students bring their own equipment to school. Because of this responsibility, some teachers may not dare to use students' own equipment. On the other hand, equality is also connected to this question. All students do not have their own equipment. Hence, a balance is needed. This can be achieved by defining clear goals, rules, and guidelines.

Pressure for change is one driving force to transform teaching and learning practices and to integrate mobile technologies into teaching and learning. Therefore, change has been included in the framework. Change influences the core curriculum, the ICT integration strategies, as well as the teacher's competencies. For instance, Wei and So (2012) highlighted that cultural, social, and technological changes affect the content and context of learning. In this study, the survey respondents reflected this change (subchapter 6.2). However, in one way or another, change was present in the case studies and teacher interviews (subchapter 5.2). One question relating to the change involves a kind of technology hype: Is technology a good starting point for educational transformation? Hefzallah (2004) questioned the use of new technology in instruction as a fad that comes and goes. Based on the literature, similar challenges are encountered over and over again. Ertmer (1999), for instance, addressed first- and second-order barriers to technology integration in the 1990s and for the most part those barriers are still valid. Grundmeyer (2014) argued that many schools have just "jumped" into the hype without enough planning or forethought and therefore may have lost many of the gains that the innovation is designed to achieve. Thus, a clear vision and detailed strategies are needed. Technology integration should also be conjoined with pedagogy.

Thus, overall, the study indicated that mobile device integration requires not only competence in teachers but also sufficient ICT infrastructure and support (both technological and pedagogical). Mobile learning also requires preparation and design. Hence, mobile technology integration in an educational context is not self-evident. It requires rethinking strategies and pedagogies, adequate resources, equipment, and support, as well as teachers' willingness to change and develop their own skills.

7.2 Contributions to the Field of Mobile Learning

The most obvious theoretical and practical implication of the study is the mobile learning framework, which was developed based on the dialogue between the literature and the data collected in three design cycles (FIGURE 31, 160). Sharples, Taylor, and Vavoula (2005) suggested that a theory of mobile learning must be tested against the following criteria:

- Is it significantly different from the current theories of classroom, workplace or lifelong learning?
- Does it account for the mobility of learners?
- Does it cover both formal and informal learning?

- Does it theorize learning as a constructive and social process?
- Does it analyze learning as a personal and situated activity mediated by technology?

First criteria suggested by Sharples, Taylor, and Vavoula (2005) emphasizes that mobile learning is significantly different from the current theories of classroom, workplace and lifelong learning. This study highlighted that, on a broad level, mobile technology can be comprehended as a part of ICT and educational technology (Chapter 3). The literature (Chapter 3) and the observations (Chapters 5 and 6) also emphasized that mobile learning faces the same challenges as other educational technologies. Also, in some cases, the differences are rather subtle (subchapter 3.2). Therefore, this study indicated that mobile learning is not that different from other types of learning particularly in a formal educational context. There is always intent to learn and the interaction dimension provides the necessary impulses that initiate the learning process. In mobile learning, the content and activity can be mediated through technology (subchapter 3.5). Therefore, this study argues that mobile learning does not differ essentially from other types of learning. The question is thus: does the theory of mobile learning need to be significantly different from the current theories? Other relevant questions are: Will there be a lasting definition of mobile learning? Do we even have a concept (namely, mobile learning) for the future, or will such a concept emerge with other learning, like blended learning or electronic learning? All things considered, what is the future of mobile learning carried out in the educational context? How, for example, are trends such as cloud-based teaching and learning shaping mobile learning in a formal educational context? Is mobile learning a fad that comes and goes, or will it be integrated into everyday educational practices?

In this study, mobile learning is seen as a teaching and learning approach that employs mobile devices to extend traditional teaching and learning and to sustain high levels of student engagement, with rich connections to other people and resources across different contexts. Thus, the designed framework does account for the mobility of learners. It also theorizes learning as a constructive and social process and analyzes learning as a personal and situated activity mediated by technology. However, the study also suggests that a great deal depends on the teacher’s planning and pedagogy. The observations (Chapters 5 and 6) indicated that the learning was rarely extended outside the classroom and that spontaneous learning rarely emerged. The observations also showed that the interaction design should receive more attention. Therefore, especially in a formal educational context, the pedagogy should be highlighted.

The questions that this study also highlights are as follows: should a mobile learning framework cover both formal and informal learning, or should there be separate frameworks that would take into account the unique contextual considerations? The earlier mobile learning frameworks (Chapter 4) have not taken a stand on the context in which the learning is happening or where the framework is situated. Vuojärvi, Eriksson, and Ruokamo (2011, 92) argued that specialized pedagogical models that create a framework for practitioners in different areas of education that exploit mobile technology are needed. The designed framework provides a solid framework for mobile learning in a formal education context, which otherwise has been missing. It integrates different mobile learning aspects and highlights complex interrelationships. It also highlights the different domains (i.e., contextual considerations, pedagogical practices, and learning results) that all influence successful mobile learning integration in a formal educational context. The earlier frameworks do not offer this kind of information (Chapter 4). More research is needed regarding mobile learning in informal everyday life, as it may appear different from mobile learning in schools and education systems and therefore open up new avenues for mobile learning research.

Overall, the study emphasized that mobile learning in an educational context should not involve merely learning with mobile devices or applications. It should offer new ways of working and interacting in different contexts inside and outside the classroom, where mobile devices support the learning process. In particular, well-planned mobile learning activity takes into consideration the context, device aspect (i.e., technology features and usability), learner aspect (i.e., learners' needs and preferences), social aspect (i.e., interactions and collaboration), and pedagogy along with the objectives and goals of the course.

7.2.1 Design and Implementation Principles Based on the Developed Framework

One contribution of the study is the design considerations and principles for formal educational context that have been compiled based on the literature (Chapter 3) and observations made in the design cycles (Chapters 4, 5, and 6). Thus, the study provides practical advice for the implementation and integration of mobile learning into the daily practice of formal education. Thus, the framework is intended for education practitioners. The following paragraphs describe these design considerations and principles in further detail. It is important to acknowledge that mobile learning is one option for organizing, extending, and enriching teaching and learning. Thus, the aim of the following considerations and principles is not to limit teaching and learning practices only to mobile learning. Instead, the aim is to highlight principles that may enable mobile learning in a formal educational context.

Contextual Considerations

As highlighted earlier, mobile learning in a formal educational context requires sufficient support and infrastructure. By taking into account contextual considerations (FIGURE 32), the school can ensure a commitment to change because mobile learning in a formal educational context requires changes. Thus, mobile learning requires institutional change, and changes in technologies, procedures, and above all pedagogy. Also, a positive atmosphere and school culture are important. The study indicated that contextual factors (i.e., school-level considerations) can either support or hinder mobile learning integration.

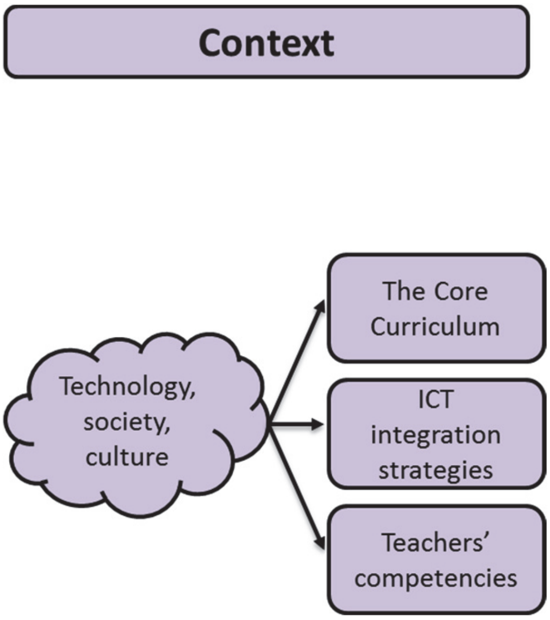

FIGURE 32 Contextual factors

Design and implementation principles relating to the contextual considerations include the following:

- Define future-oriented vision and strategies.
- Pay attention to curriculum design.
- Provide enabling ICT infrastructure.
- Provide opportunities and resources for professional development.

First, to promote mobile learning in a formal educational context, it is important to define **future-oriented vision and strategies**. These can be developed by defining goals, rules, and guidelines. The vision and strategies should cover issues related to the core curriculum, ICT integration strategies, and teachers' competencies because those factors either support or hinder mobile learning integration. Thus, the vision and strategies should highlight the cultural and strategy shift that supports and facilitates a pedagogical and procedural shift.

A **curriculum design** can facilitate the ICT and mobile learning integration. Key questions are: Does our current curriculum design support the mobile learning approach? If not, what needs to be done? For example, the study suggested that broader projects combining different subjects may provide more productive settings for mobile learning than single-subject lessons bound by an hourly schedule. Thus, integrative approaches are needed.

Other key aspects of successful mobile learning integration include the **availability of technology** and **ICT integration strategies**. Equipment should be purchased, bearing in mind institutional needs, learning goals and needs, and technological changes. Thus, the decisions should consider different devices, how those devices may enhance teaching and learning, decisions about device purchases or other strategies like BYOD, adequate networks, and adequate support (e.g., institutional, pedagogical, and technical support). These kinds of decisions should be recorded in school policy and also communicated clearly to teachers, students, and parents.

Equally important are teachers' competencies. Therefore, it is critical to provide **opportunities and resources for professional development**. For example, communities of practice, social networks, and collegial groups can provide a significant support and development channel. It is also important to acknowledge that each mobile learning implementation is different and therefore should be considered a learning opportunity, at both the school and teacher levels. Thus, sharing ideas and examples in institutions may promote mobile learning practices.

Pedagogical Considerations

Mobile learning requires purposeful pedagogical design. Pedagogical practices (i.e., teacher-level considerations) culminate in mobile learning activity and its implementation (see FIGURE 33). Actually, mobile learning does not differ substantially from other types of learning, and the design principles for effective learning also stand when designing a mobile learning activity. However, mobile learning is also unique. It is not merely e-learning with a mobile device; it has its own unique opportunities, challenges, limitations and capabilities. Therefore, the design principles need to follow the considerations for mobile learning. The basis of mobile learning activity design is pedagogical and contextual considerations, which also pay attention to learner needs and preferences, device usability, and interaction design. Thus, it is important to plan situations in which technologies like mobile devices are used, the learning goals and content, how learners will use the technology to achieve the learning goals, and how learners interact with information, devices, and each other in different contexts. The mobile learning activity design, together with the mobile learning process, affects the kind of learning experience and outcomes that will eventually form.

Design and implementation principles related to the pedagogical considerations include the following

- Assess various device functionalities and ensure device usability.
- Know learners' needs and preferences and emphasize the active role of the learner.
- Pay attention to the processes of social interaction and cooperation.
- Integrate mobile learning as a part of the learning continuum.
- Combine different learning theories, strategies, and principles.

- Offer new ways of working and interacting.
- Structure learning activities around authentic contexts and audiences.

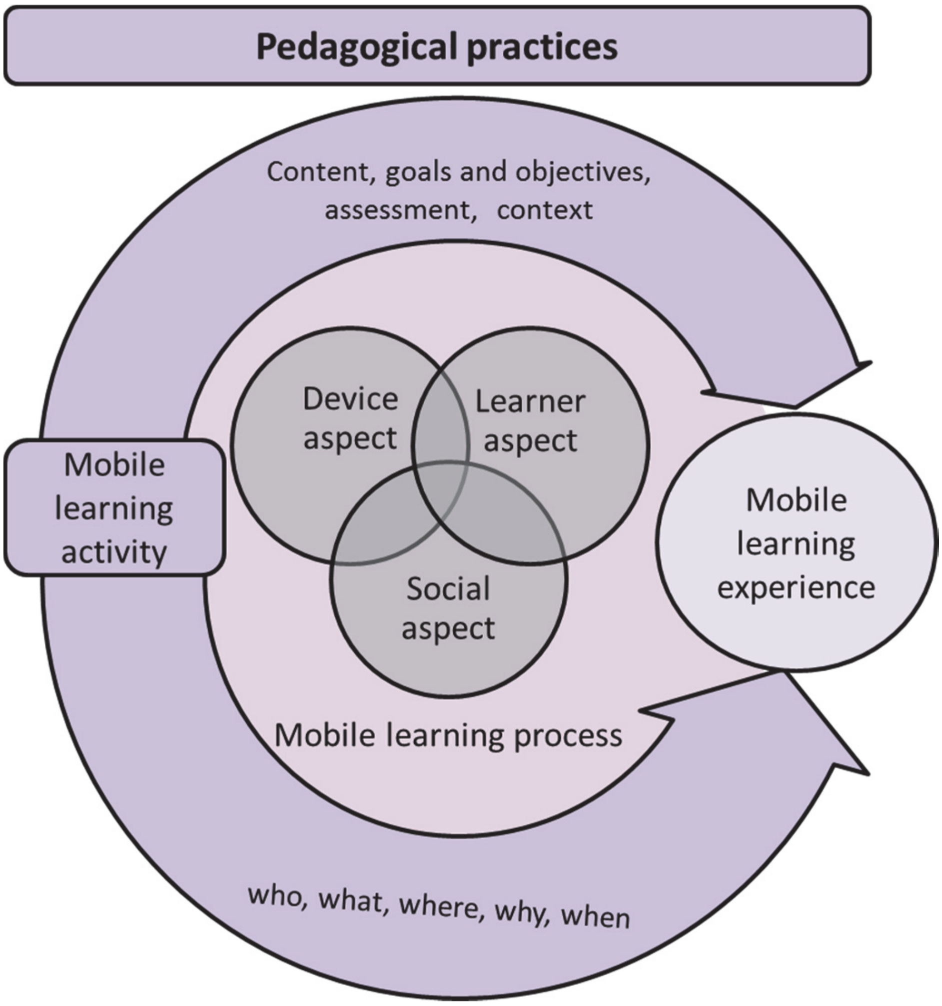

FIGURE 33 Pedagogical factors

The mobile device provides the interface between the learner and the mobile learning activity. Koole (2009) highlighted that learners equipped with well-designed devices can focus on tasks rather than the devices. Therefore, mobile technology considerations should include, among other things, device functionalities, platforms, and usability. In particular, the **usability** and **different functionalities** should be considered closely. It is also important to test various devices and applications to choose the most practical ones because mobile learning systems should be user friendly, and intuitive to be suitable and attractive for learners. The problems encountered with technology may frustrate students and distract them from the learning process. Thus, the mobile device should enable learning whenever and wherever needed spontaneously and flexibly.

Learning depends greatly on the learner and therefore the learner aspect is important. Thus, in the learner aspect, an individual learner's cognitive abilities, memory, prior knowledge, emotions, and motivations are emphasized. Therefore, it is important to **know learners’ needs and preferences**. Based on these needs and preferences, it is possible to design meaningful and sufficiently challenging activities and to provide sufficient feedback and differentiated instruction and actions if needed. A learner himself or herself actively builds up and constructs his or her knowledge and therefore the **active role of the learner** should be emphasized. Learners can have more freedom to choose the tools used and the appearance of the final output and to explore, discover, and study more in a self-directed manner. It is also important to acknowledge that some students may need more guidance or do not have sufficient skills to utilize mobile devices. Thus, issues related to the learner aspect should be considered when designing mobile learning activities.

The learning process occurs through numerous social and content interactions and therefore **interaction design** should receive attention. The processes of social interaction and cooperation should be taken into account in mobile learning activity design. In other words, how will learners interact with systems, peers, experts, and contents?

It is also important to **integrate mobile device usage as a part of the learning continuum** which includes multiple learning tasks and multidisciplinary learning; in other words, it is important to see mobile learning as more than just the use of devices and applications. Nor should it be forgotten that learning is developmental and that individuals construct new knowledge by building on their current knowledge. Therefore, linking an activity as part of a larger teaching and learning strategy and continuum is important. Thus, mobile learning is not an isolated activity or phenomenon. Although learning theories, pedagogies, and educational requirements should be the basis of mobile learning design, c**ombining different learning theories, strategies, and principles** is recommended for structuring a meaningful learning continuum.

Mobile technology should not be used only for technology’s sake or to reproduce old pedagogies or practices. It should **offer new ways of working and interacting**. Thus mobile devices provide an opportunity to transform teaching and learning practices. For instance, mobile devices provide flexibility regarding when and where learning takes place. Therefore, it is important to consider what mobile device functions can bring to teaching and learning and, especially, how they can transform teaching and learning. Does their use bring some added value (e.g., enriching and extending learning and teaching through use of mobile technology) or is the aim only to replace existing learning tools?

Also, the **change in context** (e.g., extending learning outside the classroom to an authentic real-world context and audience) should be considered. Mobile technologies in general have the unique ability to support learning anywhere and anytime as well as to expand the learning environment to authentic contexts such as parks, museums, and nature. Thus, mobile learning activities can be structured around authentic contexts and audiences.

Evaluation Considerations

The last domain in the framework includes the learning results/outcomes (FIGURE 34). The study gave some indication that mobile learning can result in a meaningful learning experience and promote learning outcomes. However, the learning outcomes should be investigated in more detail in the future.

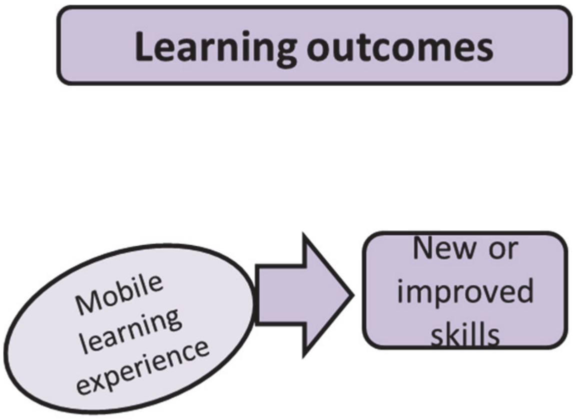

FIGURE 34 Learning outcomes

Design and implementation principles relating to the learning results include the following:

- Consider how the mobile device affects learning.
- Consider new assessment methods.
- Evaluate the implementation.

Important questions related to the learning results and outcomes are: How does the mobile device influence learning? How can such influence be evaluated? Thus, new assessment methods should be considered. The research indicated that, at its best, mobile learning can motivate learners. Thus, the integration of mobile devices can result in a positive emotional climate. Students may think that school and learning are more present-day. Thus, learning is influenced by the total environment. Overall, evaluation after the implementation is important. Were all the objectives and goal met satisfactorily? Was the approach feasible and suitable? What should be done differently? Evaluation is also important for adapting strategies and visions as well as developing pedagogies and procedures.

7.3 Trustworthiness of the Research

Before the conclusions, this subchapter discusses the trustworthiness of the research. The trustworthiness of the research was assessed using the four criteria proposed by Guba (1981): credibility, transferability, dependability, and confirmability.

First, from the credibility point of view, the triangulation method was used to increase the credibility of the study. The study employed multiple methods, sites, data, expert evaluations, and existing theory during the design, evaluation, and analysis processes. Interviews and questionnaires were the main data gathering methods in the case studies. In some cases, field observations were also recorded. During the interviews, notes were taken and the interviews were audio recorded. The data collected from interviews were transcribed. The interview notes were utilized in a transcribing process to ensure that the transcribed data were accurate. The questionnaire data were transferred to an electronic format. The questionnaires, interviews, and observation data were read through to get a general sense of the whole and the perspectives. Then the data were preliminarily organized into themes related to the aspects of mobile learning. After the initial analysis, every case was re-examined several times. Triangulation from different data was used to build a coherent justification for the themes. For example, the observations were used in conjunction with student surveys to support the conclusions. Also, examination of previous research findings was utilized to assess the results. The data analysis for the online survey followed a similar procedure. The data analyzed in design cycles two and three were also used to formulate a general view and to answer the research questions.

The data analysis and design of the framework were conducted by the researcher only. Thus, the design work of the framework did not involve participants. However, the teachers' and students' activities and feedback played significant roles in the design work. The trustworthiness of the study may have been increased by investigator triangulation using several different investigators in the analysis process, as Guion, Diehl, and McDonald (2013) indicated in their study. One crucial consideration related the study's credibility is the researcher's own assumptions and biases, which can affect the research. According to Miller (2002, 4–7), the individual researcher's personality and motivation can influence the particular direction his or her research takes. The researcher's thinking, however, was exposed to peers, experts, and participants in several ways. For example, in trying to increase the trustworthiness of the developed framework, three different methods were used: inter-researcher validation (peer debriefing: feedback from experts in scientific conferences, feedback from supervisors and colleagues), intra-researcher validation (reflecting the framework with existing mobile learning literature), and practicality and effectiveness evaluation (a try-out and field test in the form of case studies and an online survey). However, because investigator triangulation was missing, there still might be some bias. Nevertheless, in case studies, the subjectivity of the researcher and the personal involvement of the researcher are an inevitable aspect of the research (subchapter 2.3.2). Notwithstanding, it is clear that the commitment of the participants in the design process of the framework could have resulted in different aspects. Thus, the case studies should have been conducted in another way. The challenge, however, was that the empirical case studies were not designed as part of the thesis work. If the case studies had been part of the thesis work, then the survey questions and implementations would have been tailored to meet the needs of the study. Thus, it is clear that the case studies should have been conducted in another way so that they would better fit within the framework of design-based research and so that there would also be more a collaborative partnership between the researcher and practitioners. Even though the questions were not tailored for the thesis work, the data obtained valuable information about mobile learning in formal educational context and facilitated the realization of the following third cycle. Perhaps because the questions were not tailored for the thesis work, it offered new perspectives that otherwise would have escaped one's attention. Thus, perhaps this kind of realization reduced the research biases.

Attention was given to the quality of data and instruments because one clear source of error is asking the wrong questions (Kirk & Miller 1986, 22–33). According to Villar (2008), careful pretesting of the questions can detect possible bias problems. In trying to ensure that the right questions are asked, the data collection tools were tested before their actual use. The first version of the student questionnaire was tested in a small and short pilot test in the fall of 2012. Five students completed the survey. Based on the pilot test, the student survey was tailored according to the used mobile learning application and the age of the students. Also, the online survey was tested before it was distributed. Four teachers volunteered to complete the online questionnaire in the summer of 2014 and based on the teachers' feedback, the online survey was modified to its final form. Thus, the data collection tools were designed carefully and pretested; nevertheless, bias still may occur and there is no certainty about whether the right questions were asked. Thus, it should be acknowledged that no experiment can be perfectly controlled, and no measuring instrument can be perfectly calibrated (Kirk & Miller 1986, 22–33). The case studies in design cycle one were conducted in real educational settings and therefore not all of the confounding variables were controlled; this, of course, influences the repeatability of the study as well as the generalizability of the results. Preliminary appointments to the organizations and consultations with teachers were completed before the case studies and cooperation with teachers was offered during the case implementations. These procedures clearly enhanced mutual understanding as well as trust. The case studies have been described as accurately as possible. One issue of note related to the case studies is that the equipment in the case studies was loaned. The students' own equipment may have led to different outcomes. Another noteworthy issue is that the case studies were brought to the schedule after the annual planning. Thus, the outcome and the design might have been different if the mobile learning approach had been taken into account in the annual planning process.

The thick descriptions of the study should help the reader make his or her judgments about the transferability of the study. The background and the context of each case as well as the background information of the survey respondents are described as closely as possible without violating the anonymity of the participants. Because of the context-bound nature of design-based research (Plomp 2007, 16), this study does not strive to make context-free generalizations. However, analytical generalizations are sought and therefore the study discusses the applicability of the developed framework in an educational context by proposing principles/guidelines for how to implement mobile learning in a meaningful way in an educational context.

Clear limitations of the study mostly related to the sample and sample selection. First, the number of teachers and students who participated in the study was limited. Second, the sampling was nonprobability convenience sampling; in other words, in design cycles two and three, the potential participants self-selected into the sample. Thus, it should be acknowledged that the participating teachers were willing to participate in the case studies and respond to the online survey on the basis of their own interest. The online survey also included teachers who were interested in and active users of educational technology. Therefore, the responses depended on the teachers' willingness to honestly and reliably recall and report their mobile learning experiences. Also, the inexperience of the teachers who participated in the case studies versus the focused nature of the online survey respondents may have implications for the study findings. Hence, the challenge is related to response bias, which refers to factors that affect the way responses are provided. For instance, the respondent may distort the true answer, for example because he or she wants to create a positive impression (Villar 2008). Nevertheless, in qualitative research the sample selection is typically non-random, purposeful, and small (subchapter 2.3.2).

It is also important to note that cultural bias may occur. This study concentrated on mobile learning in a Finnish educational context and, therefore, the evaluation processes were conducted only on the Finnish educational context. Even though the discovered aspects and factors were similar to those identified in the literature, the mobile learning framework may appear divergent in different educational contexts. Thus, additional research is needed to verify whether the framework is adaptable to other educational contexts. It is also important to continue to research mobile learning practices and especially how those practices are transforming educational practices in the long term. Basically, statistical inference and generalizations are problematic in this study and, therefore, they were delimited. However, as already highlighted, some analytical generalizations were made based on the similar findings in the case studies, the online survey, and the literature.

From the dependability and confirmability point of view, multiple methods as well as different strategies and techniques were utilized to collect the research data. In design cycle two, four case studies were conducted, and in design cycle three, an online survey for teachers was conducted. Similar results appeared in all four cases as well as the online survey. According to Guba (1981), if similar results are found using different methods, the case for stability is strengthened. The same aspects were also highlighted in the literature. Thus, to some extent the results are consistent and, therefore, do not reflect exclusively the researcher's perspectives. The data collected were also studied several times to avoid research biases and faulty assumptions. APPENDIXES 1, 2, 3, 4, and 5 describe the data collected in the study. Not all the data are attached to this study, but all the data are available on request. The case studies and online surveys are described as closely as possible. The data collection instruments and analysis frames also appear in the appendixes. In addition, examples and quotations from the data are provided. Based on this information, the reader should be able to create a general view of the study, and replication of the study should at least be conceivable.

In summary, this research hypothesized that multiple realities can be constructed and explored and thus the aspects of trustworthiness were applied. The study employed various strategies for ensuring trustworthiness. In particular, emphasis was given to various methods. Nevertheless, a reader should keep in mind that the subjectivity and the personal involvement of the researcher were an inevitable part of the research. However, the study justifies all the decisions and approaches used. It also shows how the mobile learning framework was produced, how it was tested and revised, and why particular research methods were employed to collect the data. Therefore, the study can be considered trustworthy.

7.4 Concluding Remarks and Recommendations for Further Research

The findings in this study provide insights into and information about the practices associated with mobile learning in a Finnish educational context; the study offers a good basis for continuing with mobile learning development and research in Finland. This study particularly highlighted the important factors that affect mobile learning in a formal educational context and therefore the results can facilitate the planning, implementation, and evaluation processes of longer term and sustainable mobile learning.

FIGURE 35 illustrates the evolution of the developed mobile learning framework.

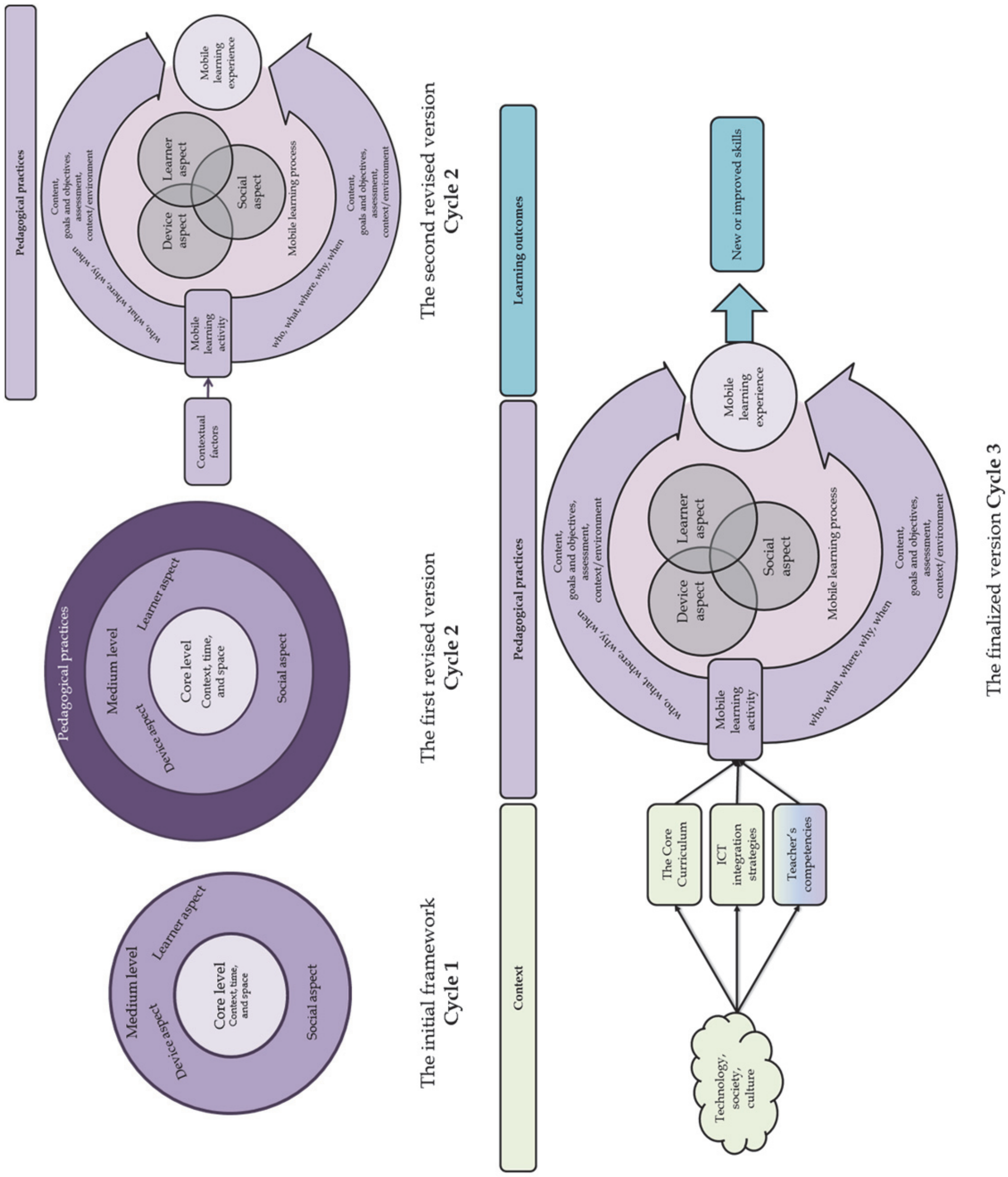

FIGURE 35 Evolution of the developed mobile learning framework

The initial mobile learning framework was constructed based on the literature and was somewhat simple (Chapter 4). It included only broad ideas regarding how the different aspects might interrelate. Therefore, the initial mobile learning framework contained only the core-level aspects (i.e., context, time, and space) and medium-level aspects (i.e., learner, device, and social aspect). The case studies in design cycle two (Chapter 5) advanced the initial mobile learning framework. The medium-level aspects (i.e., learner, device, and social aspect) were fulfilled sufficiently in all four case studies. The core-level aspects (i.e., context, time, and space) were more challenging. Design cycle two particularly highlighted the importance of pedagogical practices and therefore they were more closely scrutinized after the first two case studies. The further case studies also evoked the idea that the mobile learning process and the mobile learning experience should be reviewed separately and that the core-level aspects may be the result of mobile learning activity design and the mobile learning process. The case studies also indicated that the device, learner, and social aspects are intertwined and intersecting. Design cycle two (Chapter 5) also highlighted contextual factors. However, those factors were not added to the framework until the third design cycle (Chapter 6). Design cycle three also highlighted change. Otherwise, the framework remained similar to design cycle two. Therefore, the framework was finalized. The constant technological, social, and cultural changes, of course, will necessitate further revision of the framework in the future.

In summary, in the finalized framework (FIGURE 31, 160), the technological, societal, and cultural changes are seen to influence contextual factors such as the core curriculum, ICT infrastructure, and teachers' competencies which, in turn, either support or hinder mobile learning integration and activity design in a formal educational setting. Teachers' pedagogical practices culminate in activity design. The pedagogical practices include pedagogical and contextual considerations which pay attention to the learner, device, and social aspects (i.e., aspects of the mobile learning process). These aspects together with activity design affect the learning experience which, in turn, affects the learning outcomes. The study provided evidence that mobile devices can be used in various ways in a formal educational context to transform the educational experience. Nevertheless, mobile learning in a formal educational context is not self-evident. Not all the potential that mobile devices offer was utilized in case studies or in online survey respondents' implementations (Chapters 5 and 6). The use remained teacher-centered basic use, which does not promote students' future skills. Therefore, the study highlighted that teachers need supportive settings, technological and pedagogical competencies, support, and examples of classroom practices. Thus, mobile learning requires preparation, competent teachers, sufficient ICT infrastructure, and support.

Thus, this study has suggested a mobile learning framework (FIGURE 31, 160) and mobile learning considerations (subchapter 7.2.1) for a formal educational context. However, further research and exploration are required to study whether the aspects remain the same over time. It is also important to acknowledge that technology is evolving rapidly and next-generation devices may afford new opportunities and highlight different aspects. Supplementary research is needed to determine whether the framework is adaptable to other educational contexts. Evaluation phases were completed only in Finnish educational contexts. Earlier mobile learning frameworks around the world (TABLE 12, 81) have highlighted similar aspects to those included in the developed mobile learning framework. Thus, to some extent, the developed framework can be assumed to be adaptable. However, it is important to remember that technology-based learning activities are always constituted through a situated interaction of pupils, teachers, and technologies. Hence, other aspects may arise in different situations and contexts. Thus, many open questions remain.

The adjunct mass of experience and practice may also alter teaching practices. Therefore, it would be interesting to observe how mobile devices transform teaching and learning in the long run, especially if they become firmly established in an educational context. The study indicated that not all the potential of mobile devices has been utilized. In other words, further research questions might be: Are all potentials and opportunities discovered and employed or does mobile device use remain basic and enhancing use? Is mobile learning intrinsically short term? Does mobile learning support student-centered teaching and learning? Additional research should investigate how the use of mobile learning is transforming education.

Similarly, more thorough evaluations should be conducted. In particular, mobile learning objectives and outcomes should be measured and investigated more systematically and deeply. Therefore, longitudinal research about mobile learning is needed. Does mobile learning influence students' learning outcomes and achievements? Are mobile devices a disrupting force that leads to multitasking and hinders learning? In this study, the observations indicated that mobile learning is motivating for learners and it can produce meaningful learning experiences for diverse learners. Also, the external interaction process between the learner and the environment (e.g., with device and social interactions) is now relatively well illustrated. However, the internal psychological processes should be studied in more detail. Some guidelines regarding how mobile learning affects learners' feelings and motivation have been obtained. However, how mobile devices influence, for instance, learners' cognitive abilities and memory should also be investigated. To clarify, multidisciplinary research is required, research that combines, for instance, pedagogy, psychology, cognitive science, information technology, and brain research. This kind of research may clarify the learner aspect even further.

Also, the existing mobile learning applications should be studied. Are they developed mainly based on the behaviorist paradigm or are other conceptions of learning included in the background of the applications? Can mobile learning applications be used in various ways or do they foster a certain teaching paradigm? Do the different subjects have different needs for applications? What kinds of applications are utilized in different subjects? The importance of these questions is emphasized especially because teachers are trying to find ready-made solutions that are easy to integrate as a part of their teaching practices. This was observed especially in the case studies.

YHTEENVETO (FINNISH SUMMARY)

Tämä väitöstutkimus keskittyy mobiilioppimiseen suomalaisessa koulukontekstissa. Teknologisen kehityksen myötä erilaiset mobiililaitteet ovat yleistyneet nopeasti ja niiden mahdollisuudet osana opetusta ja oppimista on tunnistettu. Myös Suomessa mobiililaitteet (erityisesti tablet-laitteet) ovat alkaneet yleistyä opetuksessa. Mobiilioppiminen kaiken kaikkiaan on saanut osakseen hyvin paljon kiinnostusta ympäri maailmaa. Mobiilioppimisella tässä tutkimuksessa tarkoitetaankin opetuksen ja oppimisen menetelmää, joka hyödyntää mobiililaitteita perinteisen opetuksen ja oppimisen rikastamiseen sekä oppijoiden motivointiin ja aktivointiin erilaisten vuorovaikutuksen keinoin erityyppisissä oppiympäristöissä. Kirjallisuuden perusteella mobiilioppimisen teoria ja tutkimus ovat hyvin hajanaista, eikä ole olemassa yhtä yhtenäistä mallia, joka selittäisi mobiilioppimista koulukontekstissa. Tästä syystä tämän tutkimuksen tarkoituksena on kehittää mobiilioppimisen malli, joka ottaa huomioon sekä kontekstin, mobiilioppimisen erityispiirteet että pedagogiikan. Tutkimuksen tarkoituksena onkin siis kehittää sekä mobiilioppimisen teoriaa että käytäntöjä. Tutkimus on monitieteinen kehittämistutkimus (design-based research) ja tutkimuksen aineisto on pääosin laadullista aineistoa, joka on kerätty haastatteluin ja kyselyin. Tutkimus pyrki selvittämään mobiilioppimisen ydintekijöitä ja erityispiirteitä, miten nämä tekijät ja piirteet ovat suhteessa keskenään sekä mitkä muut tekijät vaikuttavat mobiiliteknologioiden hyödyntämiseen osana opetusta ja oppimista. Tutkimukseen sisältyi kolme tutkimussykliä, joiden aikana mobiilioppimisen malli suunniteltiin ja kehitettiin. Ensimmäisessä syklissä rakennettiin kirjallisuuden pohjalta alustava malli. Alustavaa mallia arvioitiin toisessa syklissä, joka sisälsi neljä tapaustutkimusta keskisuomalaisissa kouluissa syksyllä 2012. Tapaustutkimukset edistivät alustavaa mallia. Kolmas ja viimeinen sykli sisälsi verkkokyselyn opettajille kesällä 2014. Tämä kolmas sykli syvensi ymmärrystä mobiilioppimisesta sekä siihen vaikuttavista tekijöistä. Tutkimuksen aikana kehitetty mobiilioppimisen malli perustuukin sekä kirjallisuuteen että empirian kautta tehtyihin havaintoihin. Malli selventää mobiilioppimisen keskeisimpiä tekijöitä, miten ne ovat vuorovaikutussuhteessa keskenään sekä mitkä muut tekijät vaikuttavat pedagogisesti mielekkään mobiilioppimisen toteutukseen koulukontekstissa. Tutkimuksen perusteella mobiilioppimisen ydintekijöinä voidaan pitää pedagogiikkaa, oppimisympäristöä, oppijaa, laitetta sekä vuorovaikutusta. Tutkimus sisältää myös vinkkejä mobiilioppimisen toteutusta varten. Kaiken kaikkiaan tutkimus osoitti, että mobiilioppiminen koulukontekstissa ei juurikaan poikkea muun tyyppisestä oppimisesta eikä etenkään teknologia-avusteisesta oppimisesta. Kaikkia mobiililaitteen tarjoamia mahdollisuuksia ei kuitenkaan vielä osata hyödyntää. Tästä syystä tutkimus myös osoitti, että mobiilioppiminen vaatii sekä valmistelua, päteviä opettajia, asianmukaista laitteistoa kuin myös tukea (sekä teknistä että pedagogista). Parhaimmillaan tutkimuksen tulokset voivat auttaa sekä mobiilioppimisen suunnittelussa, toteutuksessa että arvioinnissa.

REFERENCES

Aaltio, I., & Heilman, P. 2010. Case Study as a Methodological Approach. In A. J. Mills, G. Durepos, & E. Wiebe (Eds.), Encyclopedia of Case Study Research. Thousand Oaks, CA: SAGE Publications, Inc., 67–78.

Abas, Z. W., & Hussain, R. M. R. 2013. Acceptance of Tablet Devices for Learning and Teaching in Institutions of Higher Learning. The Malayisan Perspective. In Z. Berge & L. Muilenburg (Eds.) Handbook of Mobile Learning. New York: Routledge, 582–591.

ADL Mobile Learning Handbook. 2011. Available in: https://sites.google.com/a/adlnet.gov/mobile-learning-guide/home/. Accessed: 27.1.2014.

Ahonen, M., Koponen, H., Syvänen, A., & Turunen, H. 2002. Digital learning - osaraportti: Uudet mobiili-innovaatiot oppimisen tukena.[Digital Learning - report: New mobile innovations to support learning]. Hämeenlinna: Hämeen ammattikorkeakoulu.

Alexandra, G.-J. 2013. Towards a Learner-Centered Approach to Teaching English. Professional Communication and Translation Studies, 6(1-2), 205–210.

Al-Hmouz, A., & Freeman, A. 2010. Learning on location: An adaptive mobile learning content framework. Technology and Society (ISTAS), 2010 IEEE International Symposium on, 450–456.

Ally, M. 2013. Mobile learning: from research to practice to Impact Education. Learning and Teaching in Higher Education: Gulf Perspectives, 10(2).

Ally, M., & Prieto-Blázquez, J. 2014. What is the future of mobile learning in education? Mobile Learning Applications in Higher Education [Special Section]. Revista de Universidad y Sociedad del Conocimiento (RUSC). Vol. 11, No 1., 142–151.

Al-Shehri, S. 2011. Connectivism: A new pathway for theorising and promoting mobilelanguage learning. International Journal of Innovation and Leadership in the Teaching of Humanities, 1 (2), 10–31.

Alvarez, C., Alarcon, R., & Nussabaum, M. 2011. Implementing collaborative learning activities in the classroom supported by one-to-one mobile computing: A design-based process. The Journal of Systems and Software 84, 1961–1976.

An, Y.-J., & Reigeluth, C. 2012. Creating Technology-Enhanced, Learner-Centered Classrooms: K–12 Teachers' Beliefs, Perceptions, Barriers, and Support Needs. Journal of Digital Learning in Teacher Education, 28(2), 54–62.

Anderson, T., & Shattuck, J. 2012. Design-Based Research: A Decade of Progress in Education Research? Educational Researcher, 41 (1), 16–25.

Anney, V.N. 2014. Ensuring the Quality of the Findings of Qualitative Research: Looking at Trustworthiness Criteria. Journal of Emerging Trends in Educational Research and Policy Studies (JETERAPS) 5(2), 272–281.

Attewell, J., Savill-Smith, C., & Douch, R. 2009. The impact of mobile learning. Examining what it means for teaching and learning. LSN.

Aveyard, Helen. 2010. Doing a Literature Review in Health and Social Care : A Practical Guide (2nd Edition). Berkshire, GBR: McGraw-Hill Education.

Baker, A., Dede, C., & Evans, J. 2014. The 8 Essentials for Mobile Learning Success in Education. Qualcomm Wireless Research. Available in: https://www.qualcomm.com/media/documents/files/the-8-essentials-for-mobile-learning-success-in-education.pdf. Accessed: 9.1.2015.

Bakker, A., & Van Eerde, H.A.A. (in press). An introduction to design based research with an example for statistics education. In A. Bikner-Ahsbahs, C. Knipping, & N. Prsemeg (Eds.), Doing qualitative research: methodology and methods in mathematics education. New York: Springer. Available in: http://www.researchgate.net/publication/256618979_An_introduction_to_design-based_research_with_an_example_from_statistics_education. Accessed: 20.2.2015.

Bandura, A. 1989. Social cognitive theory. In R. Vasta (Ed.), Annals of child development. Vol. 6. Six theories of child development. Greenwich, CT: JAI Press, 1–60.

Bannan, B. 2007. The Integrative Learning Design Framework: An Illustrated Example from the Domain of Instructional Technology. In T. Plomp and N. Nieveen (Eds.) An Introduction to Educational Design Research. Proceedings of the seminar conducted at the East China Normal University, Sanghai (PR China) November 23-26, 2007. SLO Netherlands institute for Curriculum development, 53–72.

Barab, S., & Squire, K. 2004. Design-Based Research: Putting a Stake in the Ground. The Journal of the Learning Sciences, 13(1), 1–14.

Beland, L.-P., & Murphy, R. 2015. III Communication: Technology, Disraction & Student Performance. CEP Discussion Paper No 1350 May 2015. London: Centre for Economic Perfomance. Available in: http://cep.lse.ac.uk/pubs/download/dp1350.pdf. Accesed: 19.5.2015.

Bensassi, M., & Laroussi, M. 2014. Evaluation Framework for Dependable Mobile Learning Scnearios. In I.A. Sánches and P. Isaías (Eds.), 10th International Conference on Mobile Learning, IADIS Press, 167–174.

Bernard, J. 2013. Accelerating Educational Transformation Through ICT: a Global Perspective . In L. Y. Tay & C. P. Lim (Eds.) Creating Holistic Technology-Enhanced Learning Experiences : Tales from a Future School in Singapore.Rotterdam: SensePublishers : Imprint: SensePublishers, 209-216.

Binkley, M., Erstad, O., Herman J., Raizen, S. Ripley, M., Miller-Ricci, M. & Rumble, M. 2012. Defining Twenty-First Century Skills. In P. Griffin, B. McGaw & E. Care (Eds.) Assessment and teaching of 21st century skills. New York: Springer, 17-66.

Bloem, J., van Aart, C. 2010. On Digital (Mobile) Humanism: helping understand it, engineer its future and ensure its social benefit. In: WebScience 2010.

Brandt, R. S. 1998. Powerful Learning. Alexandria, Va: Association for Supervision and Curriculum Development.

Brooks-Young, S. 2010. 21st-century skills. In Teaching with the tools kids really use: Learning with web and mobile technologies. CA: Corwin Press: Thousand Oaks.

Brown, J. S., Collins, A., & Duguid, S. 1989. Situated cognition and the culture of learning. Educational Researcher, 18(1), 32–42.

Brown, T. 2003. The role of m-learning in the future of e-learning in Africa. 21st ICDE World Conference. Available in: www.tml.hut.fi/Opinnot/T-110.556/2004/Materiaali/brown03.pdf. Accessed: 8.10.2014.

Cahill, C., Kuhn, A., Schmoll, S., Lo, W.-T., McNally, B., & Quintana, C. 2011. Mobile Learning in Museums: How Mobile Supports for Learning Influnce Student Behavior. In Proceedings of the 10th International Conference on Interaction Design and Children, ACM, New York, NY, USA, 21-28.

Capretz, L. F., & Alrasheedi, M. 2013. A Meta-Analysis of Critical Success Factors Affecting Mobile Learning. Electrical and Computer Engineering Publications. Paper 18. Available in: http://ir.lib.uwo.ca/electricalpub/18. Accessed: 14.9.2014.

Chen, D. 2003. Uncovering the Provisos behind Flexible Learning. Educational Technology & Society, 6(2), 25–30.

Chen, C.-H. 2008. Why Do Teachers Not Practice What They Believe Regarding Technology Integration? The Journal of Educational Research, Vol. 102, No. 1, 65–75.

Chen, G.D, Chang, C.K., & Wang, C.Y. 2008. Ubiquitous learning website: Scaffold learners by mobile devices with information-aware techniques. Computers & Education, 50 (2008), 77–90.

Chen, Y.-S., Kao, T.-C., & Sheu, J.-P. 2003. A Mobile Learning System for Scaffolding Bird Watching Learning. Journal of Computer Assited Learning, 19, 347–359.

Chen, Y.-S., Kao, T.-C., Yu, G.-J., & Sheu, J.-P. 2004. A Mobile Butterfly-Watching Learning System for Supporting Independent Learning. In Proceedings of the The 2nd IEEE International Workshop on Wireless and Mobile Technologies in Education (WMTE'04), JungLi,Taiwan: IEEE Computer Society, 11–18.

Chen, W., Tan, N., Looi, C.-K., Zhang, B.H., & Seow, P. 2008. Handheld computers as cognitive tools: technology-enhanced environmental learning. In, Research and Practice in Technology Enabled Learning, vol. 3, no.3., 231–252.

Cheung, W. S., & Hew, K. F. 2009. A review of research methodologies used in studies on mobile handheld devices in K-12 and higher education settings. Australasian Journal Of Educational Technology 25 (2), 153–183.

Chomsky, N. 1967. A Review of B.F. Skinner's Verbal Behavior. Language, Vol. 25, No. 1, 26–58.

Choudhary, P. 2008. Distance learning technologies in education. Jaipur, India: ABD Publishers.

Chu, H. 2014. Potential Negative Effects of Mobile Learning on Students' Learning Achievement and Cogntivie Load–A Format Assessment Perspective. Educational Technology & Society, 17(1), 332–344.

CIMO, Ministry of Education and Culture, & National Board of Education. 2013. Finnish Education in a Nutshell. Education in Finland. Available in: http://www.minedu.fi/OPM/Julkaisut/2013/Finnish_education_in_a_nutshell.html?lang=en. Accessed: 5.12.2014.

Cinque, M. 2013. The "Reflective Student". The Use of Mobile Devices Through Seamless Educational Spaces and Authentic Learning Scenarios. In Z. Berge & L. Muilenburg (Eds.) Handbook of Mobile Learning. New York: Routledge, 209–223.

Clark, C. 2012. The Technology Learning Cycle. NspireD2. Available in: ltlatnd.wordpress.com/2012/05/02/the-technology-learning-cycle/. Accessed: 3.12.2014.

Clarke, A. 2001. Designing Computer-Based Learning Materials. Abingdon, Oxon, GBR: Gower Publishing Limited.

Clough, G., Jones, A. C., McAndrew, P., & Scanlon. E. 2008. Informal learning with PDAs and smartphones. Journal of Computer Assisted Learning, 24, 359–371.

Cochrane, T. D. 2010. Exploring mobile learning success factors . ALT-J Research in Learning Technology 18 (2), 133–148.

Cohen, L., Manion, L. & Morrison, K. 2013. Research methods in education. (7th ed. edition) Abingdon: Routledge.

Colella, V. 2000. Participatory Simulations: Building collaborative understanding through immersive dynamic modeling. Journal of the Learning Sciences, 9(4), 471–500.

Conole, G. 2013. Designing for Learning in an Open World. New York, NY: Springer New York. Explorations in the Learning Sciences, Instructional Systems and Performance Technologies Volume 4 2013.

Costabile, M.F., De Angeli, A., Lanzilotti, R., Ardito, C., Buono, P. & Pederson, T. 2008. Explore! Possibilities and challenges of mobile learning. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '08). ACM, New York, NY, USA, 145–154.

Costello, P. J. M., 2003. Action research. London ; New York: Continuum. Continuum research methods series.

Creswell, J. 2012. Educational research: Planning, conducting, and evaluating quantitative and qualitative research, 4th ed. Upper Saddle River, NJ: Pearson Education.

Crompton, H. 2013a. A Historical Overview of M-learning. Toward Learner-Centered Education. In Z. Berge & L. Muilenburg (Eds.) Handbook of Mobile Learning. New York: Routledge, 3–14.

Crompton, H. 2013b. Mobile Learning: New Approach, New Theory. In Z. Berge & L. Muilenburg (Eds.) Handbook of Mobile Learning. New York: Routledge, 47–57.

Cross, S. 2009. Adult Teaching And Learning : Developing Your Practice. Maidenhead: McGraw-Hill International [UK] Ltd.

Czaja, R., & Blari, J. 2005. Designing Surveys. 2nd edition. A Sage Publications Company, Thousand Oaks: Pine Forge Press.

Davies, P. 2006. Exploratory Research. In V. Jupp (Ed.) The SAGE Dictionary of Social Research Methods.London, England: SAGE Publications, 111–112.

Design-Based Research Collective. 2003. Design-Based research: an emerging paradigm for educational inquiry. Educational Research 32 (1), 5–8.

De Marcos, L., Gutiérrez, H. R. J., Pagés, C. & Martínez, J. J. 2006. Implementing Learning Objects Repositories for Mobile Devices. ICUC 2006 Ubiquitous Computing. Proceedings of the I International Conference on Ubiquitous Computing: Applications, Technology and Social Issues. Available in: http://ftp.informatik.rwth-aachen.de/Publications/CEUR-WS/Vol-208/paper04.pdf. Accessed: 27.1.2014.

Donnelly, P., Kirk, P., & Benson, J., 2012. How to succeed at e-learning. Chichester West Sussex U.K.: John Wiley & Sons.

Dvergsdal, H. 2013. Finnish School Abandons Books for Tablets. ScienceNordic. Available in: http://sciencenordic.com/finnish-school-abandons-books-tablets. Accessed: 28.8.2014.

Edgar, D. W. 2012. Learning Theories and Historical Events Affecting Instructional Design in Education. Recitation Literacy Toward Extraction Literacy Practices. Sage Open October-December 2012, 1–9.

Elo, S., Kääriäinen, M., Kanste, O., Pölkki, T., Utriainen, K, & Kyngäs, H. 2014. Qualitative Content Analysis. A Focus on Trustworthiness. SAGE Open Feb 2014, 4 (1), 1–10.

El-Hussein, M. O. M., & Cronje, J. C. 2010. Defining Mobile Learning in the Higher Education Landscape. Educational Technology & Society, 13 (3), 12–21.

El-Mowafy, A., Kuhn, M., & Snow, T. 2013. A blended learning approach in higher education: A case study from surveying education. Teaching and Learning forum 2013. Available in: http://otl.curtin.edu.au/events/conferences/tlf/tlf2013/refereed/el-mowafy.html. Accessed: 10.10.2014.

Ericsson Mobility Report - On the Pulse of the Networked Society. 2014. Available in: http://www.ericsson.com/res/docs/2014/ericsson-mobility-report-november-2014.pdf. Accessed: 24.11.2014.

Ertmer, P.A., & Newby, T.J. 1993. Behaviorism, Cognitivism, Constructivism: Comparing Critical Features From an Instructional Design Perspective. Performance Improvement Quarterly, 6(4), 50–72.

Ertmer, P.A. 1999. Addressing first- and second-order barriers to change: Strategies for technology integration. Educational Technology Research and Development, vol. 47(7), 47–61.

Evans, C. 2008. The effectiveness of m-learning in the form of podcast revision lectures in higher education. Computers & Education, 50(2), 491–498.

Ferrari, A., Cachia, R., & Punie, Y. 2011. Educational Change through Technology: A Challenge for Obligatory Schooling in Europe. In C. D. Kloos, D. Gillet, R. M. Crespo García, F. Wild & M. Wolpers (Eds.) Towards Ubiquitous Learning : 6th European Conference of Technology Enhanced Learning, EC-TEL 2011, Palermo, Italy, September 20-23, 2011. Proceedings.Berlin, Heidelberg: Springer, 97-110.

Fink, A. (Ed.). (2003). How to Ask Survey Questions. (2nd ed.). Thousand Oaks, CA: SAGE Publications, Inc.

Finnish National Board of Education. 2014a. Education system. Available in: http://www.oph.fi/english/education_system. Accessed: 5.12.2014.

Finnish National Board of Education. 2014b. Basic education. Available in: http://www.oph.fi/english/curricula_and_qualifications/basic_education. Accessed: 5.12.2014.

Floyd, J. F. 2009. 1 Introduction. In Survey Research Methods (4th ed.). Thousand Oaks, CA: SAGE Publications, Inc., 2–11.

Frohberg, D., Göth, C., & Schwabe, G. 2009. Mobile Learning projects–a critical analysis of the state of the art. Journal of Computer Assisted Learning 25 (4), 307-331.

Futuresource Consulting. 2014a. Tablets On The Upswing In Global Education Markets, Achieve 100% Growth: Futuresource Consulting. Available in: http://www.futuresource-consulting.com/2014-09-tablets-in-education-global-press-0956.html. Accessed: 24.11.2014.

Futuresource Conslulting. 2014b. Global Education Hardware Technology Spend Hits $13 Billion. Available in: http://futuresource-consulting.com/2014-06-EducationHardware.html. Accessed: 24.11.2014.

Gaberson, K.B., Oerman, M.H., & Shellenbarger, T. 2014. Clinical Teaching Strategies in Nursing, Fourth Edition, New York, NY: Springer Publishing Company.

Garrison, D.R. 1997. Self-Directed Learning: Toward a Comprehensive Model. Adult Education Quarterly, 48(1), 18–33.

Ge, X., Huang, D., Zhang, H., & Bowers, B.B. 2013. Three-Dimension Design for Mobile Learning. Pedagogical, Design, and Technological Considreations and Implications. In Z. Berge & L. Muilenburg (Eds.) Handbook of Mobile Learning. New York: Routledge, 329–345.

Georgiev, T., Georgieva, E., & Smrikarov, A. 2004. M-Learning - a New Stage of E-Learning. The International Conference on Computer Systems and Technologies - CompSysTech. , 28-1.

Geddes, S. J. 2004. Mobile Learning in th 21st Century: Benefit for Learners. Knowledge Tree e-journal: An ejournal of flexible learning in VET 30 (3), 214–218.

Gillham, B. 2010. Case study research methods. London: Continuum International Publishing.

Glazer, F. S. 2011. Introduction. In A. J. Kezar and F. S. Glazer (Eds.) New Pedagogies and Practices for Teaching in Higher Education: Blended Learning: Across the Disciplines, Across the Academy. Sterling, VA, USA: Stylus Publishing, 1-12.

Grant, M.M., & Barbour, M.K. 2013. Mobile Teaching and Learning in the Classroom and Online: Case Studies in K-12. In Z. Berge & L. Muilenburg (Eds.), Handbook of mobile learning, New York, USA: Routledge, 285–292.

Greenwood, D. J., & Levin, M. (2007). Introduction to Action Research : Social Research for Social Change. Thousand Oaks, Calif: Sage Publications.

Grundmeyer, T. 2014. Adopting Technology: Using Student Qualitative Data and Gartner's Hype Cycle. Journal of Education and Training Studies, Vol. 2, No. 1, 207–216.

Guba, E. G. 1981. ERIC/ECTJ Annual Review Paper: Criteria for Assessing the Trustworhiness of Naturalistic Inquiries. Educational Communication and Technology, 29 (2), 75–91.

Guba, E. G., & Lincoln, Y. S. 1981. Effective evaluation. San Francisco Calif.: Jossey-Bass.

Guion, L. A., Diehl, D. C., & McDonald, D. 2011. Triangulation: Establishing the Validity of Qualitative Studies. A series of the Department of Family, Youth and Community Sciences, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. EDIS. Available in: http://edis.ifas.ufl.edu/fy394. Accessed: 28.8.2014.

Haag, J. 2012. Mobile eLearning is not mobile learning. Advanced Distributed Learning. Available in: http://www.adlnet.gov/from-adl-team-member-jason-haag-mobile-elearning-is-not-mobile-learning/. Accessed: 14.9.2014.

Hamel, J., Dufour, S., & Fortin, D. 1993. Case study methods. Newbury Park, Calif.: SAGE. Qualitative research methods.

Hancock, D., Bray, M., & Nason, S. 2002. Influencing University Students' Achievement and Motivation in a Technology Course. Journal Of Educational Research, 95 (6), 365–372.

Hanewald, R., & Ng, W. 2011. The Digital Revolution in Education: Digital Citizenship and Multi-Literacy of Mobile Technology. In W. Ng (Ed.), Mobile Technologies and Handheld Devices for Ubiquitous Learning: Research and Pedagogy. Hershey, PA: Information Science Reference, 1-14.

Harinen, P., & Halme, J. 2012. Hyvä, paha Koulu. Kouluhyvinvointia hakemassa. Suomen UNICEF Nuorisotutkimusverkosto/Nuorisotutki-musseura, verkkojulkaisuja 56. Helsinki: Unigrafia Oy. Available in: http://www.nuorisotutkimusseura.fi/julkaisuja/Hyva_paha_koulu.pdf. Accessed: 10.4.2015.

Hashim, A.S., Ahmad, W.F.W, & Ahmad, R. 2011. Usability and Effectiveness of Mobile Learning Course Content Application as a Revision Tool.Computer Technology and Application, 2, 148–157.

Hefzallah, I. M. 2004. The New Educational Technologies and Learning : Empowering Teachers to Teach and Students to Learn in the Information Age. (2nd ed. edition) Springfield: Charles C Thomas Publisher, LTD.

Heinrich, P. 2012. The iPad as a tool for education: A study of the introduction of iPads at Longfield Academy. Kent, UK: Naace.

Herrington, A. & Herrington, J. 2007. Authentic mobile learning in higher education. In: AARE 2007 International Educational Research Conference, 28 November 2007, Fremantle, Western Australia.

Herrington, J., Herrington, A., Mantei, J., Olney, I., & Ferry, B. 2009. Using mobile technologies to develop new ways of teaching and learning. In J. Herrington, A. Herrington, J. Mantei, I. Olney, and B. Ferry (Eds.), New technologies, new pedagogies: Mobile learning in higher education, Faculty of Education, University of Wollongong. Available in: http://ro.uow.edu.au/cgi/viewcontent.cgi?article=1092&context=edupapers. Accessed: 19.8.2014

Howland, J., & Wedman, J. 2004. A Process Model for Faculty Development: Individualizing Technology Learning. Journal of Technology and Teacher Education, 12(2), 239–262.

Hoy, W. K. 2010. Quantitative research in education : a primer. Los Angeles [Calif.] ; London: SAGE.

Hwang, G., & Tsai, C. 2011. Research trends in mobile and ubiquitous learning: a review of publications in selected journals from 2001 to 2010. British Journal of Educational Technology 42 (4), E65-E70.

Hwang, G.-J., Kuo, W.-L., Wu, P.-H., Huang, Y.-M., & Zhuang, Y.-Y. 2010. An Investigation on Students' Cognitive Load and Learning Achievements for Participating in a Local Culture Mobile Learning Activity. 6th IEEE International Conference on Wireless, Mobile and Ubiquitous Technologies in Education (WMUTE), 27 - 33.

Hýlen, J. 2012. Turning on mobile learning in Europe. Illustrative initiatives and policy implications. UNESCO working paper series on mobile learning. De Fontenoy, France: The United Nations Educational, Scientific and Cultural Organization

Illeris, K. 2007. How we learn: learning and non-learning in school and beyond. London: Routledge.

Illeris, K. 2009. A comprehensive understanding of human learning. In K. Illeris (Ed.) Contemporary theories of Learning. Learning theorists...in their own words. London: Routledge, 7-20.

International Data Corporation (IDC). 2013. Tablet Shipments Forecast to Top Total PC Shipments in the Fourth Quarter of 2013 and Annually by 2015, According to IDC. Available in: http://www.idc.com/getdoc.jsp?containerId=prUS24314413. Accessed: 29.11.2013.

International Data Corporation (IDC). 2014. Worldwide Smartphone Shipments Top One Billion Units for the First Time, According to IDC. Available in: http://www.idc.com/getdoc.jsp?containerId=prUS24645514. Accessed: 28.8.2014.

Issa, G., Al-Bahadili, H., & Abuhamdeh, M. 2011. A scalable framework to quantitatively evaluate success factors of mobile learning systems. International Journal of Mobile Learning and Organisation, 5 (3), 299-316.

Jalali, S., & Wohlin, C. 2012. Systematic Literature Studies: Database Searchers vs. Backward Snowballing. In Proceedings of ACM-IEEE International Symposium on Empirical Software Engineering and Measurement (ESEM) 2012, 29–38.

Jalava, T., Selkee, J., & Torsell, K. 2014. Peruskoulujen ja lukioiden tietotekniikkakartoitus 2013. Kysely kunnille ja kuntayhtymille. [ICT survey 2013 for basic and upper secondary schools. The survey for municipalities and federation of municipalities]. Helsinki, Kuntaliitto. Available in: http://www.kunnat.net/fi/Kuntaliitto/media/tiedotteet/2014/04/201404tietotekniikkakartoitus/Koulujen%20tietotekniikkakartoitus%20yhteenvetoraportti_220414.pdf. Accessed: 26.3.2015.

Jarvis, P. 2010. Adult education and lifelong learning: theory and practice. (4th ed. edition) London: Routledge.

Jesson, J. K., Lacey, F. M., & Matheson, L. 2011. Doing your literautre review: traditional and systematic techniques. London; Los Angeles: Sage Publications.

Johnnie, P. B. 1993. Formal education: A paradigm for human resource development. The International Journal of Educational Management 7(5), 4–8.

Johnson, B., & Christensen, L. 2008. Educational research: quantitative, qualitative, and mixed approaches. (3rd ed. edition) Los Angeles (Calif.): SAGE.

Johnson, L., Adams Becker, S., Estrada, V., Freeman, A., Kampylis, P., Vuorikari, R., and Punie, Y. 2014. Horizon Report Europe: 2014 Schools Edition. Luxembourg: Publications Office of the European Union, & Austin, Texas: The New Media Consortium. Available in: https://ec.europa.eu/jrc/sites/default/files/2014-nmc-horizon-report-eu-en_online.pdf. Accessed: 31.3.2015.

Jordan, A., Stack, A., & Carlile, O. 2008. Approaches to Learning : A Guide for Teachers. Maidenhead: Open University Press.

Juuti, K., & Lavonen, J. Design-based research in science education: one step towards methodology. 2006. In: NorDina: Nordisk tidsskrift i naturfagdidaktikk. 2, 54-68.

Kalloo, V., & Mohan, P. 2012. MobileMath: An innovative solution to the problem of Mathematics performance in the Carribean. Caribbean Teaching Scholar, Vol. 2, No.1., 5–18.

Kankaanranta, M., & Norrena, J. 2010. Innovatiivinen opetus ja oppiminen. Kansainvälisen ITL-tutkimuksen pilottivuoden päätulokset ja ensituloksia Suomesta. [Innovative teaching and learning: Main results and initial finding of the international ITL research based on the pilot year]. Jyväskylä, Finland: The Agora Center, Jyväskylän yliopisto.

Kankaanranta, M., Palonen, T., Kejonen, T., & Ärje, J. 2011. Tieto- ja viestintätekniikan merkitys ja käyttömahdollisuudet koulun arjessa. [The use of educational technologies in schools everyday life]. In M. Kankaanranta (Ed.) Opetusteknologia koulun arjessa. Jyväskylä: Jyväskylän yliopisto, Koulutuksen tutkimuslaitos, 47–76.

Kankaanranta, M., Neittaanmäki, P., & Nousiainen, T. (Eds). 2013. Arjen mobiilipalvelut -hankkeen oppimisen ja hyvinvoinnin mobiiliratkaisut. [Mobile solutions for learning and wellbeing]. University of Jyväskylä.

Karadeniz, S. 2009. Flexible design for the future of distance learning. Procedia–Social and Behavioral Sciences, 1(1), 358–363.

Kay, A. 1972. A Personal Computer for Children of All Ages. Proceedings of the ACM annual conference, Volume 1, Article No 1. Available in: http://dl.acm.org/citation.cfm?id=1971922. Accessed: 31.3.2015.

Kearney, M., Schuck, S., Burden, K., & Aubusson, P. 2012. Viewing mobile learning from a pedagogical perspective. Research in Learning Technology 20.

Keegan, D. 2002. The Future of Learning: From eLearning to mLearning. Ziff Papiere 119 FernUniversität. Available in:
http://files.eric.ed.gov/fulltext/ED472435.pdf. Accessed: 27.1.2014.

Keegan, D. 2005. The incorporation of mobile learning into the mainstream education and training.
. mLearn 2005, 4th World Conference on m-learning.

Keith, F. P. 2003. Survey Research. London, England: SAGE Publications Ltd.

Kerka, S. (2000). Incidental learning: trends and issues, Alert No. 18: Education Resource Information Centre. Available in:
http://www.eric.ed.gov/PDFS/ED446234.pdf. Accessed: 28.3.2015.

Keskín, N., & Metcalf, D. 2011. The Current Perspectives, Theories and Practices of Mobile Learning. Turkish Online Journal Of Educational Technology, 10(2), 202-208.

Kirk, J., & Miller, M. L. 1986. Reliability and validity. In Reliability and Validity in Qualitative Research. Newbury Park, CA: SAGE Publications, 14-22.

Koehler, M. J., & Mishra, P. 2009. What is technological pedagogical content knowledge? Contemporary Issues in Technology and Teacher Education, 9(1), 60-70.

Kolb, D.A. 1984. Experiential learning: experience as the source of learning and development. Englewood Cliffs, NJ: Prentice Hall.

Koole, M. L. 2009. A Model for Framing Mobile Learning. In M. Ally (Ed.) Mobile Learning: Transforming the Delivery of Education and Training.Edmonton, AB, CAN: Athabasca University Press, 25-50.

Krzywacki, H., Pehkonen, L., & Laine, A. 2012. Promoting Mathematical Thinking in Finnish Mathematics Education. In H. Niemi, A. Toom, & A. Kallioniemi (Eds.) Miracle of Education. The Principles and Practices of Teaching and Learning in Finnish Schools. Rotterdam: Sense Publishers, 115–130.

Kukulska-Hulme, A. 2009. Will mobile learning change language learning? ReCall, 21(2), 157–165.

Kukulska-Hulme, A., & Shield, L. 2008. An overview of mobile assisted language learning: From content delivery to supported collaboration and interaction. ReCALL, 20(3), 271–289.

Lam, P., Kowk, M., & Wong, K. 2011. Support and promotion of mobile learning strategies. In G. Williams, P. Statham, N. Brown & B. Cleland (Eds.), Changing Demands, Changing Directions. Proceedings ascilite Hobart 2011, 758–762.

Lam, J., Yau, J., & Cheung, S. 2010. A Review of Mobile Learning in the Mobile Age. Hybrid Learning. In Proceedings of the Third international conference on Hybrid learning (ICHL'10), P. Tsang, S. K. Cheung, V. S. K. Lee, and R. Huang (Eds.) Springer-Verlag, Berling, Heidelberg, 306-315.

Lam, S.L., Wong, K., Mohan, J., Xu, D., & Lam, P. 2011. Classroom communication on mobile phones–first experiences with web-based 'clicker' system. In Proceedings of ASCILITE - Australian Society for Computers in Learning in Tertiary Education Annual Conference 2011, 763–777.

Laouris, Y., & Eteokleous, N. 2005. We need an educationally relevant definition of mobile learning. 2005, the 4th World Conference on Mobile Learning. Cape Town, South Africa.

Laru, J. 2012. Scaffolding Learning Activities with Collaborative Scripts and Mobile Devices. Acta Universitatis Ouluensis. Series E, Scientiae rerum socialium 125. University of Oulu.

Lassila, A., & Teivainen, A. 2014. Men left behind as gender gap in education widens. News From Finland Helsinki Times, 20 Mar 2014. Available in: http://www.helsinkitimes.fi/finland/finland-news/domestic/9904-men-left-behind-as-gender-gap-in-education-widens.html. Accessed: 7.8.2014.

Lave, J., & Wagner, E. 1991. Situated learning. Legitimate peripheral participation. Cambridge Unviersity Press.

Lavonen, J., & Juuti, K. 2012. Science at Finnish Compulsory School. 2012. In H. Niemi, A. Toom, & A. Kallioniemi (Eds.) Miracle of Education. The Principles and Practices of Teaching and Learning in Finnish Schools. Rotterdam: Sense Publishers, 131–148.

Law, C., & So, S., 2010. QR codes in education. Journal of Educational Technology Development and Exchange, 3(1), 85–100.

Lee, J.-K., Lee, I.-S., & Kwon, Y.-J. 2011. Scan & Learn! Use of Quick Response Codes & Smartphones in a Biology Field Study. The American Biology Teacher, Vol. 73, No. 8, 485–492.

Lefoe, G., Olney, I., Wrigth, R., & Herrington, A. 2009. Faculty development for new technologies: Putting mobile learning in the hands of the teachers. In J. Herrington, A. Herrington, J. Mantei, I. Olney, and B. Ferry (Eds.) New technologies, new pedagogies: Mobile learning in higher education, Faculty of Education, University of Wollongong, New South Wales, Australia, 15–27.

Lehner, F., & Nösekabel, H. 2002. The role of mobile devices in E-Learning first experiences with a wireless E-Learning environment. Proceedings of the IEEE International Workshop on Wireless and Mobile Technologies in Education, 2002, 103–106.
Leinonen, T., Keune, A., Veermans, M., & Toikkanen, T. 2014. Mobile apps for reflection in learning: A design research in K-12 education. British Journal of Educational Technology.
Leonard, D. C. 2002. Learning Theories, A to Z. Westport, Conn: Oryx Press. Available in: eBook Collection (EBSCOhost), Ipswich, MA. Accessed: 19.8.2014.
Li, S.-C., & Chun, K.-K. 2011. Apply Problem-Based Learning in Mobile Learning Enviroment. 11th IEEE International Conference on Advanced Learning Technologies (ICALT) 2011, 129–130.
Lincoln, Y. (2004). Trustworthiness Criteria. In Michael S. Lewis-Beck, A. Bryman, & Tim Futing Liao (Eds.), The SAGE Encyclopedia of Social Science Research Methods. Thousand Oaks, CA: Sage Publications, 1145–1146.
Liu, H., Salomaa, J., Huang, R., & Ma, D.2008. An Activity-Oriented Design Framework for Mobile Learning Experience. Fifth IEEE International Conference on Wireless, Mobile, and Ubiquitous Technology in Education, 2008. (WMUTE), 185–187.
London Mobile Learning Group. 2014. Theory. Available in: http://www.londonmobilelearning.net/#theory.php. Accessed: 27.1.2014.
Low, L., & O'Connel, M. 2006. Learner-centric design of digital mobile learning. Online Learning and Teaching Conference–OLT Conference 2006. Brisbane, Australia.
Martin, W. E., & Bridgmon, K. D., 2012. Quantitative and statistical research methods : from hypothesis to results. (1st ed. edition) San Francisco: Jossey-Bass. Research methods for the social sciences.
Mascolo, M. F. 2009. Beyond student-centered and teacher-centered pedagogy: Teaching and learning as guided participation. Pedagogy and the Human Sciences, 1(1), 3–27.
Maslow, A. H. 1943. A Theory of Human Motivation. Psychological Review, 50, 370–396.
McGinn, M. 2010. Credibility. In Albert J. Mills, G. Durepos, & E. Wiebe (Eds.), Encyclopedia of Case Study Research. Thousand Oaks, CA: SAGE Publications, 243–245.
McLeod, S. A. 2008. Case Study Method. Available in: http://www.simplypsychology.org/case-study.html. Accessed: 20.9.2014.
Mercer, N., & Littleton, K. 2007. Dialogue and the development of children's thinking : a sociocultural approach. London New York,: Routledge.
Merriam, S. B. 2009. Qualitative research: a guide to design and implementation. San Francisco (Calif.): Jossey-Bass. The Jossey-Bass higher and adult education series.

Milard, M., Wong, L.-H., Sharples, M., Hwang, G.-H., Looi, C.-K., & Ogata, H. Seamless Learning. An International Perspective on Next-Generation Technology-Enhanced Learning. In Z. Berge & L. Muilenburg (Eds.) Handbook of Mobile Learning. New York: Routledge, 95–108.

Miller, P. H. 2002. Theories of developmental psychology. (4th ed. edition) New York: Worth Publishers.

Miller, A. 2011. Twelve Ideas for Teaching with QR Codes. Available in: http://www.edutopia.org/blog/QR-codes-teaching-andrew-miller. Accessed: 8.12.2014.

Mohammad, M., & Mohammad, H., 2012. Computer Integration into the Early Childhood Curriculum. Education, vol. 133(1), 97–116.

Mostakhdemin-Hosseini, A., & Tuimala, J. 2005. Mobile learning framework. In P. Isaias, C. Borg, P. Kommers & P. Bonnanon (Eds.) Proceedings of the IADIS International Conference on Mobile Learning , 203–207.

Motiwalla, L. F. 2007. Mobile Learning: A Framework and Evaluation. Computers & Education, 49, 581–596.

Moura, A., & Carvalho, A. A. 2013. Framework for Mobile-Learning Integration Into Educational Contexts. In Z. L. Berge, & L. Y. Muilenburg. Handbook of Mobile Learning. New York, USA: Routledge, 58–69 .

Murphy, J., Dean, E., & Hill, C. A. 2014. Social Media, Sociality, and Survey Research. Hoboken, New Jersey: Wiley.

Murphy, M. E. 2014. Why Some Schools Are Selling All Their iPads. The Atlantic. Available in: http://www.theatlantic.com/education/archive/2014/08/whats-the best-device-for-interactive-learning/375567/. Accessed: 20.8.2014.

Naismith, L., Lonsdale, P. Vavoula, G., & Sharples, M. 2005. Report 11: Literature review in mobile technologies and learning. NESTA Futurelab Series. Available in: http://archive.futurelab.org.uk/resources/documents/lit_reviews/Mobile_Review.pdf. Accessed: 13.8.2012.

Naismith, L., & Corlett, D. 2006. Reflections on Success: A retrospective of the mLearn conference series 2002-2005. mLearn 2006: Across generations and cultures. Banff, Canada.

National Board of Education. 2000. Core Curriculum for Pre-School Education in Finland. Helsinki: Yliopistopaino.

Ng, W., & Nicholas, H. 2013. A framework for sustainable mobile learning in schools. British Journal of Educational Technology (5), 695–715.

Nicholas, H. 2011. Ubiquitous Computing Does Not Guarantee Ubiquitous Learning in Schools: The Case of Handheld Computers. In W. Ng (Ed.), Mobile Technologies and Handheld Devices for Ubiquitous Learning: Research and Pedagogy. Hershey, PA: Information Science Reference, 30-44.

Nordin, N., Mohamed, A. E., & Melor, M. Y. 2010. Mobile Learning Framework for Lifelong Learning. Procedia - Social and Behavioral Sciences 7, 130-138.

Norrena, J. -M., Kankaanranta, M., & Nieminen, M. 2011. Kohti innovatiivisia opetuskäytänteitä. In M. Kankaanranta (Ed.) Opetusteknologia Koulun Arjessa. [Educational technologies in school]. Jyväskylä: University of Jyväskylä Finnish Institute for Educational Research and Agora Center, 77–100.

Norris, C.A., & Soloway, E.M. 2013. Substantive Educational Change is in the Palm of our Children's Hands. In Z. L. Berge, & L. Y. Muilenburg. Handbook of Mobile Learning. New York, USA: Routledge, 109–118 .

Nussabaum, M., Alvarez, C., McFarlane, A., Gomez, F., Claro, S, & Radovic, D. 2009. Technology as small group face-to-face Collaborative Scaffolding. Computers & Education 52, 147–153.

Obrenović, Ž. 2011. Design-based research: what we learn when we engage in design of interactive systems. interactions 18, 5, 56–59.

OECD. 2013. Education at a Glance 2013: OECD Indicators. OECD Publishing. Available in: http://dx.doi.org/10.1787/eag-2013-en. Accessed: 23.9.2014.

O'Malley, C., Vavoula, G., Glew, J. P., Taylor, J., Sharples, M. & Lefrere, P. 2005. Guidelines for learning/teaching/tutoring in a mobile environment. MOBIlearn - Pedagogical Methodologies and Paradigms 4.

Opeka. 2014. Opeka questionnaire Recent results. Available in: http://opeka.fi/en. Accessed: 27.3.2015.

Opetushallitus. 2014. Opettajat Suomessa. [Teachers in Finland]. T. Kumpulainen (Ed.). Koulutuksen seurantaraportit 2014:8. Available in: http://oph.fi/download/156282_opettajat_suomessa_2013.pdf. Accessed: 23.9.2014.

Opetushallitus. 2015. OPS 2016. Available in: http://www.oph.fi/ops2016. Accessed: 15.5.2015.

Opetus- ja kulttuuriministeriö. 2012. Tulevaisuuden perusopetus – valtakunnalliset tavoitteet ja tuntijako. Opetus- ja kulttuuriministeriön työryhmämuistioita ja selvityksiä 2012:6. Opetus- ja kulttuuriministeriö, Koulutuspolitiikan osasto.

Opetusministeriö. 2000. Turvatyöryhmän muistio. [Committee on Safety at School]. Opetusministeriön työryhmien muistioita 20:2000, Opetusministeriö.

Oppiminen. 2014. Opetusympäristöt. Available in: http://www.oppiminen.fi. Accessed: 16.12.2014.

Osawa, N., Noda, K., Tsukagoshi, S., Noma, Y., Ando, A., Shibuya, T., & Kondo, K. 2007. Outdoor Education Support System with Location Awareness Using RFID and Symbology Tags. Journal of Educational Multimedia and Hypermedia, 16(4), 411–428.

Osborne, J., & Hennessy, S. 2003. Literature review in science education and the role of ICT: Promise, problems and future directions. Available in: http://telearn.archives-ouvertes.fr/docs/00/19/04/41/PDF/osborne-j-2003-r6.pdf. Accessed: 9.10.2014.

Osman, M., El-Hussein, M., & Cronje, J. 2010. Defining Mobile Learning in the Higher Education Landscape. Educational Technology & Society 13 (3), 12–21.

Ozdamli, F., & Cavus, N. 2011. Basic elements and characteristics of mobile learning. Procedia - Social and Behavioral Sciences 28, 937–942.

Ozdamli, F. 2012. Pedagogical framework of m-leraning. Procedia - Socal and Behavioral Sciences Volume 31, 927–931.

Pankin, J., Roberts, J., & Savio, M. 2012. Blended Learning at MIT. Available in: http://web.mit.edu/training/trainers/resources/blended_learning_at_mit.pdf. Accessed: 9.10.2014.

Park, Y. 2011. A pedagogical framework for mobile learning: Categorizing educational applications of mobile technologies into four types. The International Review of Research in Open and Distance Learning 12 (2).

Parsons, D., Ryu, H., & Cranshaw, M. 2007. A Design Requirements Framework for Mobile Learning Environments, Journal of Computers, 2(4), 1–8.

Passey, D. 2010. Mobile Learning in School Contexts: Can Teachers Alone Make It Happen? IEEE Transactions on Learning Technologies 3(1), 68–81.

Passey D. 2014. Inclusive Technology Enhanced Learning: Overcoming Cognitive, Physical, Emotional, And Geographic Challenges [e-book]. New York: Routledge. Available in: eBook Collection (EBSCOhost), Ipswich, MA. Accessed: 19.8.2014.

Pass, S. 2004. Parallel Paths to Constructivism : Jean Piaget and Lev Vygotsky. Greenwich, Conn: Information Age Pub.

Patten, B., Arnedillo-Sánchez, I., & Tangney, B. 2006. Designing collaborative, constructionist and contextual applications for handheld devices. Computers & Education, 46, 294–308.

Peer Group. (2006). How does DBR differ from other approaches. In a PEER Tutorial for Design-based Research. Available in: http://dbr.coe.uga.edu/explain02.htm#third. Accessed: 3.11.2014.

Peng, H., Su, Y., Chou, C., & Tsai, C. 2009. Ubiquitous knowledge construction: mobile learning re-defined and a conceptual framework. Innovations in Education and Teaching International 46 (2), 171–183.

Peters, K. 2005. Learning On The Move: Mobile Technologies in Business and Education, Australian. Flexible Learning Framework.

Peters, K. 2007. m-Learning: Positioning educators for a mobile, connected fugure. The International Review of Research in Open and Distance Learning, 8(2). Available in: http://www.irrodl.org/index.php/irrodl/article/view/350/894. Accessed: 9.10.2014.

Peters, K. 2009. M-learning: Positioning Educators for a Mobile, Connected Future. In M. Ally (Ed.) Mobile Learning: Transforming the Delivery of Education and Training.Edmonton, AB, CAN: Athabasca University Press, 113–132.

Piaget, J. 1936. Origins of intelligence in the child. London: Routledge & Kegan Paul.

Pitler, H., Hubbell, E. R., & Kuhn, M. 2012. Using technology with classroom instruction that works /. (2nd ed. edition) Alexandria, Va.: Association for Supervision and Curriculum Development.

Plomp, T. 2007. Educational Design Research: and intoduction. In T. Plomp and N. Nieveen (Eds.) An Introduction to Educational Design Research. Proceedings of the seminar conducted at the East China Normal University, Sanghai (PR China) November 23-26, 2007. SLO Netherlands institute for Curriculum development, 9–36.

Poutala, M. 2010. Opettajan valta ja vastuu. [The teacher's powers and responsibilities]. Jyväskylä: PS-Kustannus.

Prasertsilp, P. 2013. Mobile Learning: Designing a Socio-Technicla Model to Empower Learning in Higher Education, LUX: A Journal of Transdisciplinary Writing and Research from Claremont Graduate Unviersity, 2(1), Article 23.

Puentedura, R. R. 2009. As We May Teach: Educational Technology, From Theory Into Practice. Available in: https://itunes.apple.com/itunes-u/as-we-may-teach-educational/id380294705?mt=10#ls=1. Accessed: 15.8.2014.

Puranen, T., Helfstein, S., & Lappalainen, V. 2009. InSitu – Technical Description and Preliminary Evaluation of a TCP/IP Connection-based Teaching and Learning Communication System. Paper presented at eLAC 2009 – Conference. Available in: https://dl.dropboxusercontent.com/u/228641/PuranenHelfensteinLappalainen_InSitu_eLAC2009.pdf. Accessed: 12.11.2014.

Puri, U. 2006. Teaching Techniques. Delhi, IND: Pragun Publications.

Quinn, C. 2000. mLearning: Mobile, Wireless, In-Your-Pocket Learning. Available in: http://www.linezine.com/2.1/features/cqmmwiyp.htm. Accessed: 27.1.2014.

Reeves, T. C. 2000. Enhancing the Worth of Instructional Technology Research through "Design Experiments" and Other Development Research Strategies. Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans, LA, USA.

Reeves, T. 2006. Design research from a technology perspective. In J. V. D. Akker, K. Gravemeijer, S. McKenney & N. Nieveen (Eds.), Educational design research. New York: Routledge, 52–66.

Rikala, J. 2011. InSitu ja aktiivinen oppiminen [InSitu and active learning]. Master's thesis. Department of mathematical information technology. University of Jyväskylä.

Rikala, J. 2013. Mobile Learning a Review of Current Research. Reports of the Department of Mathematical Information Technology. Series E. Educational Technology, No. E2/2013. Jyväskylä: Univeristy of Jyväskylä.

Rikala, J. 2014a. Evaluating QR Code Case Studies Using a Mobile Learning Framework. In I.A. Sánches and P. Isaías (Eds.), 10th International Conference on Mobile Learning, IADIS Press, 199–206.

Rikala, J. 2014b. Evaluating the Nature Tour Mobile Learning Application. In Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2014. Chesapeake, VA: AACE, 1675–1683.

Rikala, J. 2014c. Developing a Cohesive Mobile Learning Framework. In R. Ørngreen and K.T. Levinsen (Eds.) Proceedings of the 13th European Conference on e-Learning ECEL-2014. Academic Conferences and Publishing International Limited, 720–724 .

Rikala, J., Hiltunen, L., & Vesisenaho, M. 2014. Teachers' Attitudes, Competencies, and Readiness to Adopt Mobile Learning Approaches. In Proceedings of 2014 IEEE Frontiers in Education Conference. IEEE, 2529–2536.

Rikala, J., & Kankaanranta, M. 2012. The Use of Quick Response Codes in the Classroom . In M. Specht, J. Multisilta & M. Sharples (Eds.) mLearn 2012 Mobile and Contextual Learning. Proceedings of the 11th International Conference on Mobile and Contextual Learning 2012, CELSTEC & CICERO Learning, 148–155.

Rikala, J., & Kankaanranta, M. 2014a. Blending Classroom Teaching and Learning with QR Codes. In I.A. Sánches and P. Isaías (Eds.), 10th International Conference on Mobile Learning, IADIS Press, 141–148.

Rikala, J., & Kankaanranta, M. 2014b. The Nature Tour Mobile Learning Application. Implementing the Mobile Application in Finnish Early Childhood Education Settings. In S. Zvacek, M. Restivo, J. Uhomoibhi, & M. Helfert (Eds.), Proceedings of the 6th International Conference on Computer Supported Education : Volume 3, SCITEPRESS - Science and Technology Publications, 171–178.

Rikala, J., Vesisenaho, M., & Mylläri, J. 2013. Actual and potential pedagogical use of tablets in schools. Human Technology 9(2), 113–131.

Ritchie, D., & Baylor, A. 1997. Teaching with Technology. TechTrends 42 (4), 27–30.

Robson, C. 2002. Real World Research. (Second edition) Malden, USA: Blackwell Publishing.

Rogers, Y., Price, S. Harris, E., Phelps, T., Underwood, M., Wilde, D., & Smith, H. 2002. Learning through digitally-augmented physical experiences: Reflections on the Ambient Wood project. Available in: http://python.espe-bretagne.fr/master-hst-ue9-2/wp-content/uploads/Rogers_Ambient_Wood2.pdf. Accessed: 13.9.2014.

Rogers, Y., & Price, S. 2009. How Mobile Technologies are Changing the Way Children Learn. In A. Druin (Ed.) Mobile Technology for Children. Designing for Interaction and Learning. Burlington, USA: Elsevier, 3–22.

Roschelle, J. 2003. Keynote paper: Unlocking the learning value of wireless mobile devices. Journal of Computer Assisted Learning 19 (3), 260–272.

Rosen, A. 2009. E-learning 2.0 : proven practices and emerging technologies to achieve real results. New York: AMACOM/American Management Association.

Rushby, N. 2012. Editorial: An agenda for mobile learning. British Journal of Educational Technology (3), 355–356.

Sana, F., Weston, T., & Cepeda, N. J. 2013. Laptop multitasking hinders classroom learning for both users and nearby peers, Computers & Education 62, 24–31.

Sapsford, R. J. 2006. Survey Research. London: SAGE Publications Ltd.

Savery, J. R. 2006. Overview of problem-based learning: Definitions and distinctions. Purdue e-Pubs.

Savin-Baden, M., & Howell, C. 2004. Foundations of problem based learning (Trans.). Berkshire, GBR: MCGraw-Hill Education.

Scanlon, E., Gaved, M., Jones, A. Kukulska-Hulme, A., Paletta, L., & Dunwell, I. 2014. Representations of an incidental learning framework to support mobile learning. In I.A. Sánches and P. Isaías (Eds.), 10th International Conference on Mobile Learning, IADIS Press, 238–242.

Schofield, C. P., West, T., & Taylor, E. 2011. Going Mobile in Executive Education. How Mobile Technologies are Changing the Executive Learning Landscape. Research for UNICON. Aschridge. Available in: https://www.ashridge.org.uk/Media-Library/Ashridge/PDFs/Publications/GoingMobileInExecutiveEducation.pdf. Accessed: 20.8.2014.

Schonlau, M., Fricker, R. D., & Elliott, M. N. 2002. Conducting Research Surveys Via E-mail and the Web. Santa Monica, CA: Rand.

Schunk, D. H. 2012. Learning theories : an educational perspective. (6th ed. edition) Boston MA ; London: Pearson.

Scott, K.M., Kitching, S., Burn, D., Koulias, M., Campbell, D., & Phelps, M. 2010. "Wherever, whenever" learning in Medicine: Interactive mobile case-based roject. In C.H. Steel, M.J. Keppell, P. Gerbic & S. Housego (Eds.), Curriculum, technology & transformation for an unknown future. Proceedings ascilite Sydney 2010, 888–890.

Seol, S., Sharp, A., & Kim, P. 2012. Use of a Mobile Application to Promote Scientific Discovery Learning: Students' Perceptions towards and Practical Adoption of a Mobile Application.In Proceedings of the 13th annual conference on Information technology education (SIGITE '12). ACM, New York, NY, USA, 121-126.

Serrano-Santoyo, A., & Organista-Sandoval, J. 2010. Challenges and opportunities to support learning with mobile devices. Proceedings of the 3rd Mexican Workshop on Human Computer Interaction. San Luis Potosi Mexico, 85–87.

Sha, L., Looi, C.–K., Chen, W., & Zhang, B. H., 2012. Understanding mobile learning from the perspective of self-regulated learning. Journal of Computer Assisted Learning 28 (4), 366–378.

Sharples, M. 2013. Mobile learning: research, practice and challenges. Distance Education in China, 3(5), 5–11.

Sharples, M., Taylor, J., & Vavoula, G. 2005. Towards a theory of mobile learning. Proceedings of mLearn 2005, 1(1), 1–9.

Sharples, M., Taylor, J., & Vavoula, G. 2007. A Theory of Learning for the Mobile Age. In R. Andrews & C. Haythornthwaite (Eds.) The Sage Handbook of Elearning Research.London: Sage, 221-247.

Shear, L., Gallagher, G., & Patel, D. 2011. Evolving educational ecosystems: Executive summary of Phase I ITL Research results. Redmond, WA: Microsoft Corporation.

Shih, J.-L., Chuang, C.-W., & Hwang, G.-J. 2010. An Inquiry-based Mobile Learning Approach to Enhancing Social Science Learning Effectiveness. Educational Technology & Society, 13 (4), 50–62.

Shih, J.-L., Chu, H.-C., Hwang, G-J., & Kinshuk. 2011. An investigation of attitudes of students and teachers about participating in a context-aware ubiquitous learning activity. British Journal of Educational Technology 42(3), 373–394.

Shin, D-H., Jung, J., & Chang, B.-H. 2012. The psychology behing QR codes: User experience perspective. Computers in Human Behavior, 28, 1417–1426.

Shoaf, M. M, Pollak, H., & Schneider, J. 2004. Math Trails. The Consortium for Mathematics and Its Applications. COMAP, Inc., Lexington, USA. Available in: http://www.comap.com/highschool/projects/mathtrails/MathTrails.pdf. Accessed: 19.12.2013.

Shuler, C. 2009. Pockets of Potential: Using Mobile Technologies to Promote Children's Learning, New York: The Joan Ganz Cooney Center at Sesame Workshop.

Silverman, D., & Marvasti, A. 2008. Doing qualitative research: a comprehensive guide. Los Angeles (Calif.): SAGE Publications.

Siemens, G. 2004. Connectivism: A Learning Theory for the Digital Age. elearnspace everything elearning. Available in: http://www.elearnspace.org/Articles/connectivism.htm. Accessed: 19.8.2014.

Simons, H. 2009. Case study research in practice. London ; Thousand Oaks, Calif.: Sage.

Skinner, B.F. 1974. About Behaviorism. New York: Aflred A. Knopf, Inc.

So, H.-J., Kim, I., & Looi, C.-K. 2008. Seamless Mobile Learning: Possibilities and Challenges Arising from the Singapore Experience. Educational Technology International , Vol. 9, No. 2, 97–121.

Sonquist, J. A., & Dunkelberg, W. C. 1977. Survey and opinion research : Procedures for processing and analysis. Englewood Cliffs N.J.

Stanton, G., & Ophoff, J. 2013. Towards a Method for Mobile Learning Design. Issues in Informing Science and Information Technology, Vol. 10, 501 - 523.

Staples, A., Pugach, M., & Himes, D. 2011. Rethinking the Technology Integration Challenge: Cases from Three Urban Elementary Schools. In L. Schrum (Ed.) Considerations on educational technology integration : the best of JRTE. (1st ed. edition) Eugene Or.: International Society for Technology in Education, 9–40.

Stemberger, T., & Cencic, M. 2014. Design-based research in an educational research context. Sodobna Pedagogika vol. 65, no. 1, 62–89.

Stoerger, S. 2013. Becoming a Digital Nomad: Transforming Education Through Mobile Devices. In Z. L., Berge and L. Y. Muilenburg (Eds.), Handbook of Mobile Learning. New York, NY: Routledge, 473–482.

Sue, V. M., & Ritter, L. A. 2007. Conducting Online Surveys. Los Angeles: Sage Publications, 2007. eBook Collection (EBSCOhost), EBSCOhost. Accessed: 20.9.2014.

Sullo, R. 2007. Activating The Desire To Learn [e-book]. Alexandria, Va: Association for Supervision and Curriculum Development. Available in: eBook Collection (EBSCOhost), Ipswich, MA. Accessed: 18.8.2014.

Suoninen, A. 2010. Children's Media Use as Described By Their Parents. In S. Kotilainen (Ed.) Children's media barometer 2010: the Use of Media among 0-8-year olds in Finland. Helsinki: Finnish Society on Media Education, 9–14.

Suopohja, H. & Liusvaara, L. 2000. Oikeudellinen vastuu opetustoimessa. [Judicial responsibility in teaching action]. Helsinki: Mediator legis.

Tainio, L., & Grünthal, S. 2012. Language and Literature Education: Principles and Reflections on Mother Tongue and Literature. In H. Niemi, A. Toom, & A. Kallioniemi (Eds.) Miracle of Education. The Principles and Practices of Teaching and Learning in Finnish Schools. Rotterdam: Sense Publishers, 149–160.

Tan, T.-H., Liu, T.-Y., & Chang, C.-C. 2007. Development and Evaluation of an RFID-based Ubiquitous Learning Environment for Outdoor Learning. Interactive Learning Environments, vol. 15, no. 3., 253–269.

Tan, Q., Zhang, X., Kinshuk, & McGreal, R. 2011. The 5R Adaptation Framework for Location Based Mobile Learning Systems. Proceedings of 10th World Conference on Mobile and Contextual Learning, Beijing, 87-94.

Tay, L.Y., Liam, S.K., & Lim, C.P. 2013. Factors affecting the ICT integration and implementation of one-to-one computing learning environment in a primary school–a sociocultural perspective. In L.Y. Tay and C.P. Lim (Eds.), Creating holistic learning experiences. Tales from a future school in Singapore. Rotterdam: SensePublishers, 19–37.

Tétard, F., Patokorpi, E., & Carlsson, J. 2008. A Conceptual Framework for Mobile Learning. Research Report 3/2008, Institute for Advanced Management Systems Research (IAMSR), Åbo Akademi, Turku, Finland.

Thomas, R. M. 2003. Blending qualitative & quantitative research methods in theses and dissertations. Thousand Oaks Calif.: Corwin.

Timmons, V., & Cairns, E. 2010. Case Study Research in Education. In Albert J. Mills, G. Durepos, & E. Wiebe (Eds.), Encyclopedia of Case Study Research. Thousand Oaks, CA: SAGE Publications, Inc., 100–103.

Toppo, G. 2007. Study gives teachers barely passing grade in classroom. USA TODAY. Available in: http://usatoday30.usatoday.com/news/education/2007-03-29-teacher-study_N.htm Accessed: 17.9.2014.

Traxler, J. 2005a. Defining mobile learning. IADIS International Conference Mobile Learning. , 261–266.
Traxler, J. 2005b. Mobile learning: it's here but what is it? WARWICK Interactions Journal, Issue 25, Vol. 9, No. 1. Available in: http://www2.warwick.ac.uk/services/ldc/resource/interactions/issues/issue25/traxler. Accessed: 18.9.2014.
Traxler, J. 2007. Defining, Discussing and Evaluating Mobile Learning: The moving finger writes and having writ . . . . The International Review of Research in Open and Distance Learning 8 (2).
Traxler, J. 2009a. Current State of Mobile Learning. In M. Ally (Ed.) Transforming the delivery of education and training.Edmonton: Athabasca University Press, 9–24.
Traxler, J. 2009b. Learning in a Mobile Age. International Journal of Mobile and Blended Learning, 1(1), 1–12.
Traxler, J., & Koole, M. 2014. The Theory Paper: What is the Future of Mobile Learning?, In I.A. Sánches and P. Isaías (Eds.), 10th International Conference on Mobile Learning, IADIS Press, 289–293.
Trifonova, A. 2003. Mobile learning–Review of the literature. Technical Report DIT- 03 -009, Informatica e Telecomunicazioni, University of Trento. Available in: http://eprints.biblio.unitn.it/archive/00000359/01/009.pdf. Accessed: 27.1.2014.
Tryphon, A., & Vonéche, J. 1996. Introduction. In , A. Tryphon & J. Vonéche (Eds.) Piaget–Vygotsky. The Social Genesis of Thought. East Sussex, UK: Psychology Press, 1–10.
Tsai, S., & Machado, P. 2002. E-Learning Basics: Essay E-learning, online learning, web-based learning, or distance learning: unveiling the ambiguity in current terminology. eLearn 7, 3. Available in: http://elearnmag.acm.org/archive.cfm?aid=568597. Accessed: 22.8.2014.
UNESCO. 2011. Mobile Learning Week Report. 12-16 December 2011, UNESCO HQ Paris. Available in: http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/ED/ICT/pdf/UNESCO%20MLW%20report%20final%2019jan.pdf. Accessed: 14.9.2014.
Union of Upper Secondary School Students in Finland 2013. Kehityksen paikka. Selvitys lukiolaisten suhteesta tieto- ja viestintätekniikkaan sekä sähköisiin oppimateriaaleihin. [The place for development. The study for upper secondary school students about their relationship to ICT and e-learning materials]. Helsinki, The Union of Upper Secondary School Students in Finland. Available in: http://www.lukio.fi/site/assets/files/24825/sll_kehityksen_paikka.pdf. Accessed: 26.3.2015.
Vahtivuori-Hänninen, S., & Kynäslahti, H. 2012. ICTs in a School's Everyday Life. In H. Niemi, A. Toom, & A. Kallioniemi (Eds.) Miracle of Education. The Principles and Practices of Teaching and Learning in Finnish Schools. Rotterdam: Sense Publishers, 237–248.

van den Akker, J. 2007. Curriculum Design Research. In In T. Plomp and N. Nieveen (Eds.) An Introduction to Educational Design Research. Proceedings of the seminar conducted at the East China Normal University, Sanghai (PR China) November 23-26, 2007. SLO Netherlands institute for Curriculum development, 97–52.

Vavoula, G. N., & Sharples, M. 2002. KLeOS: a personal, mobile, knowledge and learning organisation system. Proceedings of the IEEE International Workshop on Wireless and Mobile Technologies in Education WMTE'02. Växjö, Sweden.

Vavoula, G.N. 2004. KLeOS: A Knowledge and Learning Organisation System in Support of Lifelong Learning. Electronic, Electrical and Computer Engineering. Birmingham, University of Birmingham.

Viberg, O., & Grönlund, Å. 2012. Mobile Assisted Language Learning: A Literature Review. In M. Specht, J. Multisilta & M. Sharples (Eds.) mLearn 2012 Mobile and Contextual Learning. Proceedings of the 11th International Conference on Mobile and Contextual Learning 2012, Helsinki, 9–16.

Villar, A. 2008. Response Bias. In Paul J. Lavrakas (Ed.), Encyclopedia of Survey Research Methods. Thousand Oaks, CA: Sage Publications, Inc., 752–754.

Vitikka, E., Krokfors, L., & Hurmerinta, E. 2012. The Finnish National Core Curriculum: Structure and Development. In H. Niemi, A. Toom, & A. Kallioniemi (Eds.) Miracle of Education. The Principles and Practices of Teaching and Learning in Finnish Schools. Rotterdam: Sense Publishers, 83–96.

Vogt, W. P. 2005. Exploratory Research. In W. P. Vogt (Ed.) Dictionary of Statistics & Methodology. (3rd edition edition) Thousand Oaks, CA: SAGE Publications, 114–115.

Vuojärvi, H., Eriksson, M. & Ruokamo, H. 2011. Towards a Pedagogical Model for Work-Based Mobile Learning in Tourism Education. In H. Ruokamo, M. Eriksson, L. Pekkala & H. Vuojärvi (Eds.) The Social Media in the Middle of Nowhere – NBE 2011 Conference. Proceedings of the 4th International Network-Based Education 2011 Conference. June 20–23, 2011. Sallatunturi, Finland. University of Lapland, Publications in Education 25. Rovaniemi: University of Lapland Press.

Vygotskij, L. S. 1979. Thought and language (Translated by E. Hanfmann & G. Vakar. 14th pr.). Cambridge, Massachusetts: The M.I.T Press.

Walker, K. 2006. Introduction: mapping the landscape of mobile learning. In M. Sharples (Ed.) Big issues in mobile learning. Nottingham: Kaleidoscope, 3–4.

Wang, F., & Hannafin, M. J. 2005. Design-based research and technology-enhanced learning environments. Educational Technology Research and Development, *53*(4), 5–23.

Wang, Y., Wu, M., & Wang, H. 2009. Investigating the Determinants and Age and Gender Differences in the Acceptance of Mobile Learning. BJET - British Journal of Educational Technology 40, 92–118.

Wei, Y., & So, H. 2012. A Three-level Evaluation Framework For a Systematic Review of Contextual Mobile Learning. In M. Specht, J. Multisilta & M. Sharples (Eds.) Proceedings of the 11th International Conference on Mobile and Contextual Learning 2012. Helsinki , 164–171.

Westwood, P. S. 2004. Learning And Learning Difficulties : A Handbook For Teachers [e-book]. Camberwell, Vic: ACER Press. Available in: eBook Collection (EBSCOhost), Ipswich, MA. Accessed: 18.8.2014.

Wiseman, D. G., & Hunt, G. 2008. Best Practice in Motivation and Management in the Classroom : An Integrative Approach. Springfield: Charles C Thomas Publisher, LTD, 2008. eBook Collection (EBSCOhost), EBSCOhost. Accessed: 20.9.2014.

Xie, A.Z., Zhu, Q., & Xia, H.W. 2011. Investigating college major differences in the need of mobile phone learning. In proceedings of International Conference of Multimedia Technology (ICMT), 399–402.

Yahya, S., Ahmad, E. A., & Jalil, K. A. 2010. The definition and characteristics of ubiquitous learning: A discussion. International Journal of Education and Development using Information and Communication Technology (IJEDICT), 6(1), 117 - 127.

Yin, R. K. 1989. Case study research : design and methods. (Rev. ed. edition) Newbury Park Calif.: Sage. Applied social research methods series.

Yle. 2012. Tech-savvy preschoolers embrace iPads. Yle News. Available in: http://yle.fi/uutiset/tech-savvy_preschoolers_embrace_ipads/6255966. Accessed: 28.8.2014.

Ylönen, J. 2014, October 6. Vantaa hankkii 16 000 tablettia. Kuntalehti. Avalable in: http://kuntalehti.fi/kuntauutiset/vantaa-hankkii-16-000-tablettia/. Accessed: 5.12.2014.

Zhang, B., Looi, C., Seow, P., Chia, G., Wong, L., Chen, W., So, H., Soloway, E., & Norris, C. 2010. Deconstructing and reconstructing: Transforming primary science learning via a mobilized curriculum. Comput.Educ. 55 (4), 1504–1523.

APPENDIX 1: DESCRIPTION OF THE DATA COLLECTED IN THE MATH TRAIL CASE

INTERVIEWS AND QUESTIONNAIRES	**Teacher**	Interview [39 minutes, transcript 15 pages]
	Student	Questionnaire [N=24]
OTHER DOCUMENTS	**Memo**	Teacher's comments before the interview [1 pages]
	E-mail	Teacher's e-mail about students' test grades [1 page]

APPENDIX 2: DESCRIPTION OF THE DATA COLLECTED IN THE LITERATURE TREE CASE

INTERVIEWS AND QUESTIONNAIRES	**Teacher**	Interview [N=3, 32 minutes, transcript 11 pages]
	Student	Questionnaire [N=16]
OTHER DOCUMENTS	**Memo**	The initial meeting notes [1 page]
	Field notes	Field observations [3 pages]

APPENDIX 3: DESCRIPTION OF THE DATA COLLECTED IN THE NATURE TOUR CASE

INTERVIEWS AND QUESTIONNAIRES	**Teacher**	Interview [N=3, 37 minutes, transcript 11 pages]
OTHER DOCUMENTS	**Memo**	Teacher's comments during the experiment [1 page]

APPENDIX 4: DESCRIPTION OF THE DATA COLLECTED IN THE LEAF STRUCTURE CASE

INTERVIEWS AND QUESTIONNAIRES	**Teacher**	E-mail interview/questionnaire [3 pages]
	Student	Questionnaire [N=19]
OTHER DOCUMENTS	**Memo**	Comments on the initial meeting [1 pages]

APPENDIX 5: DESCRIPTION OF THE DATA COLLECTED IN DESIGN CYCLE THREE

INTERVIEWS AND QUESTIONNAIRES	**Teacher**	Online survey [N=77]

APPENDIX 6: MATH TRAIL CASE – STUDENT QUESTIONNAIRE

1	**Gender**	Girl	48%
		Boy	52%
2	**I own a mobile device.**	Yes	100%
		No	0%
3	**I had already used mobile devices for learning before this activity.**	Yes	57%
		No	39%
4	**I learned new things about the mobile device usage.**	Not at all	30%
		Somewhat	43%
		A lot	26%
5	**I needed help with the mobile application.**	Not at all	78%
		Somewhat	22%
		A lot	0%
6	**Reading from the screen was easy.**	Disagree	0%
		Agree	100%
7	**I had to learn many things before I learned how to use phone and mobile applications.**	Disagree	87%
		Agree	13%
8	**The phone always functioned as I expected.**	Disagree	35%
		Agree	61%
9	**I had already used QR codes before this activity.**	Disagree	74%
		Agree	26%
10	**It was easy to use QR codes.**	Disagree	0%
		Agree	100%
11	**The QR reader always functioned as I wanted.**	Disagree	35%
		Agree	61%
12	**I would like to do QR activities again.**	Disagree	0%
		Agree	100%
13	**QR activities were an interesting new way to learn mathematics.**	Disagree	0%
		Agree	100%
14	**I prefer traditional teaching and learning methods.**	Disagree	100%
		Agree	0%
15	**I learned mathematics with QR codes.**	Not at all	22%
		Somewhat	65%
		A lot	13%
16	**I needed help with the math problems.**	Not at all	74%
		Somewhat	26%
		A lot	0%
17	**QR codes made decimal problems more interesting.**	Not at all	13%
		Somewhat	35%
		A lot	52%

(continues)

APPENDIX 6 (continues)

18	**Rate the Nature Tour mobile application. (Missing answers 1)**	Fantastic	39%
		Very good	35%
		Nice	22%
		Passable	0%
		I did not like it	0%

19 **What did you learn?**

I learned to solve decimal problems a little bit better.
It was easier to solve math problems with QR activities. Well, mathematics better.
I learned to use a different kind of smartphone.
I learned to navigate and to use a smartphone.
Nothing much.
Nothing new.
To solve math problems by phone.
Solving math problems better.
I learned to solve different kinds of decimal problems.
To solve math problems by phone.
I learned to navigate and to use a smartphone. :-D
To solve math problems.
I did not learn anything because I already knew how to solve them.
Nothing.
Nothing new.
Nothing new.
Nothing new.
To solve decimal problems and to use a smartphone.
To solve decimal problems.
Nothing.
To solve decimal problems and to use a smartphone.
I don't know.
I did not learn. I already knew them.

20 **What else would you like to say about QR code activity?**

It was nice.
It was fun.
The Math Trail activity was fun, but sometimes when I was scanning the code, the code reader became blurry.
I would like to do it again.
Nice.
It was nice! :-)
Nothing
Good experiment!
It was fun.
It was nice to search the codes. I had to press many times answer before something happens.
Nothing.
It was an interesting new way to learn, but the math problems could have been more difficult.
It was fun as you were able to use a phone.
It was nice to solve math problems :-) !
It was nice!
It zooms by itself and that was annoying
It was fun.
Quite many bugs. There are better apps for iOS and Android.
Top!
Nothing.
It was nice. Really nice.
It was fantastic!

APPENDIX 7: MATH TRAIL CASE – TEACHER INTERVIEW QUESTIONS

Background information

- Age
- Teaching experience

Mobile learning experiment

- Was the device/application familiar to you?
- Have you implemented teaching with the device/application before this experiment?
- Was the implementation difficult or easy?
- What were the challenges?
- What were the opportunities?
- What were the positive experiences?
- What were the negative experiences?
- Did you need support during the experiment (e.g., technological, pedagogical)
- What kind of successes or failures you experienced during the experiment?
- Did you use some kind of pedagogical model?
- What kind of pedagogical model is suitable for mobile learning?
- How did your role/work changed during the experiment?
- What is your opinion about mobile learning compared to traditional learning?
- What kind of skills mobile learning requires?
- What was the additional value of mobile learning?
- Compare the time you spend designing and implementing of mobile learning versus traditional teaching and learning
- What kind of skills and competencies you would need to implement mobile learning?
- Have you participated in mobile learning training sessions?
- Do you think that you would need training and what kind of training need do you have?
- What do you think how QR codes could be used in an educational context?
- Did the students give feedback about the mobile activity?
- Was there some kind of negative student expressions?
- Do you think that you could implement these types of activities again in the future?
- Did the mobile device disturb teaching and learning somehow?
- What did you learn during this experiment?

APPENDIX 8: LITERATURE TREE CASE – STUDENT QUESTIONNAIRE

1	**Gender**	Girl	56%
		Boy	44%
2	**I own a mobile device.**	Yes	100%
		No	0%
3	**I had already used mobile devices for learning before this activity.**	Yes	69%
		No	31%
4	**I learned new things with the application.**	Not at all	69%
		Somewhat	25%
		A lot	6%
5	**I learned new things about the mobile device usage.**	Not at all	56%
		Somewhat	38%
		A lot	6%
6	**I used time to read the information text.**	Not at all	13%
		Somewhat	69%
		A lot	19%
7	**I needed help with the mobile application.**	Not at all	56%
		Somewhat	44%
		A lot	0%
8	**I had already used QR codes before this activity.**	Disagree	63%
		Agree	38%
9	**I would like to do QR activities again.**	Disagree	25%
		Agree	63%
		Missing answers	2
10	**The phone always functioned as I expected.**	Disagree	44%
		Agree	56%
11	**The QR reader always functioned as I wanted.**	Disagree	56%
		Agree	38%
		Missing answer	1
12	**I had to learn many things before I learned how to use phone and mobile applications.**	Disagree	100%
		Agree	0%
13	**It was easy to use QR codes.**	Disagree	0%
		Agree	94%
		Missing answers	1
14	**QR activities were motivating**	Disagree	25%
		Agree	63%
		Missing answers	2

(continues)

APPENDIX 8 (continues)

15	**Attention was drawn to technology.**	Disagree	69%
		Agree	19%
		Missing answers	2
16	**Reading from the screen was easy.**	Disagree	13%
		Agree	81%
		Missing answers	1
17	**QR activities were an interesting new way to learn.**	Disagree	19%
		Agree	75%
		Missing answers	1
18	**QR codes are useless.**	Disagree	88%
		Agree	6%
		Missing answers	1
19	**QR activities can be used more often.**	Disagree	25%
		Agree	69%
		Missing answers	1
20	**I prefer traditional teaching and learning methods.**	Disagree	25%
		Agree	50%
		Missing answers	4
21	**What did you learn?** I did not know that QR codes can be scanned with the mobile phone. At the end, it was easy. It was similar as searching information. Nothing. Hardly anything. I learn to revise the lessons learned and they became better to mind. They were a handy way to revise the lessons learned. A little about the literature history. That such a technology is good for learning. Unnecessary shit! 1/5. The stages of the literature history cleared and I also learned to scan QR codes. Some new things that I had not heard in class.		
22	**What else would you like to say about QR activity?** It was quite OK and thrilling :-) It was quite confusing. Quite funny. Nice. Quite nice :-) It was nice. Hopefully, more often. The use of codes was already familiar to me and they could be used more often. It was fun. Relaxing. It was nice and different. Shit. :-) It was nice and different.		

APPENDIX 9: LITERATURE TREE CASE – TEACHER INTERVIEW QUESTIONS

Background information

- Teaching experience
- Do you have previous mobile learning experiences?
- Overall, how familiar issue mobile learning is to you?

Mobile learning experiment

- Describe how the QR code trail functioned and how it fit to the group?
- Was it easy to link the QR code usage to your own pedagogy?
- Was it hard to implement this kind of activity (e.g., did it take more time)?
- Do you think that you could implement similar QR code trail again (e.g., do you now have sufficient skills?)
- Were there some technical problems during the experiment?
- Did you need support (technical and pedagogical) during the experiment?
- Was the device/application easy to use?
- Did the students need support during the experiment?
- Could the students choose the pace and methods for their learning?
- How the QR activity suited for the students?
- Was there need to diversify or personalize the trail somehow?
- What kind of reactions students had during the experiment?
- Was the QR trail motivating and meaningful for the students?
- What were the learning outcomes?
- What kind of changes the QR codes bring to teaching and learning?
- Do you think that you could use QR codes or mobile devices as a part of your teaching practices again?
- What do you think how QR codes could be used in an educational context?
- What did you learn during this experiment?

APPENDIX 10: NATURE TOUR CASE – TEACHER INTERVIEW QUESTIONS

Background information

- Teaching experience
- Do you have previous mobile learning experiences?
- Overall, how familiar issue mobile learning is to you?

Mobile learning experiment

- When and how did you utilize the mobile application?
- Was it easy to link the application usage to your own pedagogy and everyday practices?
- How suitable the application was for your purposes?
- Was it hard to implement this kind of activity (e.g., did it take more time)?
- Were there some technical problems during the experiment?
- Did you need support (technical and pedagogical) during the experiment?
- What were the additional values of the application compared to other technologies that you use?
- Were the children able to use the application self-directed?
- Were the learning situations realistic and meaningful for the children?
- Were there positive/negative child expressions?
- Did the children explore the subject different or deeper ways?
- What kind of interactions/collaboration emerged?
- What was the attitude of the parents?
- What were the learning outcomes?
- What kind opportunities or challenges there were?
- What kind of successes of failures you experienced during the experiment?
- Was the application suitable for all children? How would you develop the application?
- Would you use the application again?
- What did you learn during this experiment?
- What else would you like to say?

APPENDIX 11: LEAF STRUCTURE CASE – STUDENT QUESTIONNAIRE

1	**Gender**	Girl	47%
		Boy	47%
		Empty answers	5%
2	**The Nature Tour mobile application inspired me to observe nature.**	Not at all	0%
		Somewhat	16%
		A lot	89%
3	**I recorded plant observations with the application.**	Not at all	0%
		Somewhat	11%
		A lot	89%
4	**I recorded other things with the application.**	Not at all	37%
		Somewhat	26%
		A lot	37%
5	**I used time to read the information text.**	Not at all	21%
		Somewhat	53%
		A lot	21%
6	**I learned new things with the application.**	Not at all	0%
		Somewhat	21%
		A lot	79%
7	**I learned new things about the mobile device usage.**	Not at all	16%
		Somewhat	5%
		A lot	79%
8	**I needed help with the mobile application.**	Not at all	42%
		Somewhat	42%
		A lot	16%
9	**I think that the Nature Tour mobile application was easy to use.**	Disagree	11%
		Agree	89%
10	**The use of the Nature Tour mobile application was interesting.**	Disagree	11%
		Agree	89%
11	**Recording observations was fun.**	Disagree	0%
		Agree	100%
12	**I would like to use the Nature Tour mobile application again.**	Disagree	5%
		Agree	95%
13	**Reading from the screen was easy.**	Disagree	11%
		Agree	89%
14	**The phone always functioned as I assumed.**	Disagree	47%
		Agree	53%

(continues)

APPENDIX 11 (continues)

15	**Rate the Nature Tour mobile application.**	Fantastic	32%
		Very good	37%
		Nice	11%
		Passable	5%
		I did not like it	0%

16 **What else would you like to say about the Nature Tour mobile application?**

I don’t know.
It was nice to use a mobile device.
Nothing.
It was nice to be on a field trip and recording observation pictures.
It was really nice.
It was nice to record observation pictures.
It was nice.
Nice.
The field trip was nice.
Nice!
Really nice.
It was fantastic!

APPENDIX 12: LEAF STRUCTURE CASE – TEACHER E-MAIL INTERVIEW QUESTIONS

Background information

- Describe your teaching experience
- Do you have previous mobile learning experiences?
- Overall, how familiar issue mobile learning is to you?

Mobile learning experiment

- Describe as precisely as possible how did you utilize Nature Tour application.
- Were you able to link the application usage into your own pedagogy easily?
- Did the implementation required a lot of time?
- Did you need support during the experiment (e.g., technological, pedagogical)?
- Were the learning situations realistic and meaningful for the students?
- Was the application suitable for all students?
- Was there need to adapt or diversify the learning activity somehow?
- Did the application inspired students to observe nature? How the students' inspiration and interest appeared?
- Did the application motivated students?
- Did the students explore the subject different or deeper ways?
- What were the learning outcomes?
- What changes the mobile application brought to teaching and learning?
- What kind opportunities or challenges there were?
- What kind of successes of failures you experienced during the experiment?
- Do you think that you could utilize this application or similar as a part of your teaching practices again?
- What else would you like to say about mobile device usage in an educational context?
- What did you learn during the experiment?

APPENDIX 13: DESIGN CYCLE TWO – ONLINE SURVEY

Mobile device utilization

Mobile device in this survey refers to handheld and easy to carry device (e.g. smart phone, tablet device, mini laptop, digital player, digital camera, game console, GPS locator, PDAs)

Gender

- Male
- Female

Age

- < 25 years
- 25-29
- 30-39
- 40-49
- 50-59
- > 60 years

Home County

- Åland
- Southern Finland
- Western Finland
- Province of Oulu
- Province of Eastern Finland
- Province of Lapland

How long have you been as a teacher?

- Less than one year
- Less than 5 years
- 6-10 years
- 11-20 years
- More than 20 years

How often have you utilized mobile devices as a part of your teaching practices?

- Daily
- Weekly
- Monthly
- Less frequently
- I have not used

Why you decided to begin utilize mobile devices as a part of your teaching practices?

Are you willing to use ICT as a part of your teaching practices?

- Yes
- No

Do you think that you have sufficient skills to utilize mobile technologies as a part of teaching and learning practices?

- Yes
- No

Do you think that the mobile device integration into classroom has been easy?

- Yes
- No

Explain briefly why or why not.

Give some example how you have utilized mobile devices as a part of your teaching?

(describe and explain, for instance, the objectives, target audience, teaching subject, working methods, interactions, assessment, the factors that supported the implementaton, the challenges)

What else would you like to say about mobile device usage in an educational context?

APPENDIX 14: EXAMPLES OF MOBILE LEARNING RESEARCH

Author(s) (Year)	Research purpose	Data collection method(s)	Duration	Participants	Main findings
Al-Khalifa (2011)	To develop and implement Mobile Snapshot response system.	Black box testing technique, The System Usability Scale (SUS).	Thirty test cases.	Students (N=7).	Factors that might affect the experiment result can be attributed to the quality of the QR reader software and the reliability of the internet connection. The results showed that the system can help in improving the communications between teachers and students. Students are able to answer short assessments at the end of each class in an easy and convenient way. The system enables timely feedback and it automatically analyses student's answers.
Chen et al. (2008)	To investigate whether the handheld computers as cognitive tools can facilitate students' inquiry-based learning.	Pre-test & post-test, Questionnaire, Interviews, Students' artefacts, KWL table	5 activities	Primary grade 4 students (N=79)	The results indicated improvements in the students' understanding of the environmental issues. The students took more responsibility for their own learning. Students were more interested, motivated and engaged in learning. Students perceived that their learning activities were more organized. Handheld applications allow students to construct knowledge and they also support self-reflection. The learning tasks structured by handheld computers are situated in meaningful real-world contexts. When thinking and designing learning activities using mobile technologies, we need to focus more on the learners than the technologies. Learning occurs as a result of using technology as mediating tools over curriculum and pedagogy.
Chen & Huang (2012)	To develop a context-aware ubiquitous learning system.	UTAUT questionnaire, Pre-test & post-test	Course: 2 weeks Experiment: 370 minutes	4 teachers and grade 6 students (N=80) Randomly assigned to the experimental group and the control group	The proposed approach was able to provide more interesting learning scenarios to students and fostering a positive attitude toward learning. The results of a posttest survey revealed that most students' testing scores improved significantly. Most students thought that the system was easy to use and that it was useful in learning.

(continues)

APPENDIX 14 (continues)

Author(s) (Year)	Research purpose	Data collection method(s)	Duration	Participants	Main findings
Chong et al. (2011)	The paper examined the factors affecting the adoption of mobile learning in Malaysia.	Extended TAM questionnaire		University students (N=181)	The most important outcome of this study is to identify the four factors that are influencing the attitude towards using m-learning and consequently, the increase in the adoption rate. They are perceived ease of use, perceived usefulness, quality of services and cultural aspects.
Churchill l & Hedbergn (2008)	To investigate the effective design of learning objects on mobile device.	Semi-structured interview, Observations	Implementation: two lessons	Educational professionals (N=10=	Recommendations for design are: design for landscape and a full screen presentation, design for one step interaction, minimize scrolling, design for short contact time, design to match the task, enabling zooming capability to enlarge display beyond the physical limits of the screen, and design to include movable, collapsible, overlapping, semi-transparent interactive panels.
Clough et al. (2008)	To investigate whether, and to what extent, experienced users of mobile devices use their mobile devices to support intentional informal learning.	A web-based questionnaire	Study was conducted over a 4-week period	N=200.	The results suggested that mobile devices were used extensively in an informal learning context and that they were used in a ways that correspond to the collaborative, contextual and constructivist mobile learning philosophies. Users used mobile technologies, to support both intentional and unintentional mobile informal learning.
Costabile et al. (2008)	To evaluate possibilities and challenges of m-learning system.	Naturalistic observations, Questionnaire, Structured interviews, Focus groups, Drawings and essays, Post-test	Experiment: 2days	Pupils aged 12 (N=42)	The users enjoyed playing the game. The two game conditions gave different behavioral and social patterns. There were no significant differences in learning outcomes of the two games conditions. The evaluation indicated that mobile games require more interaction freedom and, possibly, some context-dependent information to enhance the overall user experience.
Dyson et al. (2009)	To investigate how the mobile technology can enhance active, experiential learning.	Questionnaire, Observations, Reflective teaching journals		University students and teachers.	With the exception of lecture podcasting, all cases supported high quality experiential learning. Embedding active, experiential m-learning into mainstream courses is possible. This can be achieved by paying attention to economic sustainability and ensuring that the effort required by the lecturer is not excessive. The use of a student owned equipment removed the security issue for the academics. Some of the multiple functions confused students and reduced the level of comfort in using devices effectively but overall students enjoyed.

(continues)

APPENDIX 14 (continues)

Author(s) (Year)	Research purpose	Data collection method(s)	Duration	Participants	Main findings
Ford & Leinonen (2009)	The aim was to design teaching and learning environments for formal and informal learning.	Observations		Pilot 1: The learners ranged from age 15 to 16 and came from a private school in South Africa. Pilot 2: The learners came from a local government middle school in South Africa. Pilot3: 10 learners aged 13-14.	A mobile phone as a technology tool for aid the learning process can work extremely well. The issue of sustainability and affordability will need to be clearly understood. There is a lot of "under the table" use of mobile phones in classrooms. The appropriate use of these instruments can be encouraged through values-based principles. The developed system enables all people in the developing world not only to access information, but also to contribute information back.
Fozdar & Kumar (2007)	The main aim of this study was to understand and measure students' attitudes and perceptions towards the effectiveness of mobile learning.	Questionnaire		N=65	Only 29.2% of the respondents were aware of mobile learning. 54 of the 65 respondents reported owning a mobile phone. This suggests that mobile technologies are rapidly becoming more ubiquitous and, arguably, more accessible to a larger number of learners in India. Very few reported that they were using it for web-browsing or for learning purposes. Students thought that mobile learning can be an effective method of learning, mobile learning will bring new opportunities of learning, mobile learning will be more flexible method of learning and mobile learning will improve communication between a students and teacher. The student's preferences for mobile learning were: receiving feedback on assignments, information regarding important dates, receiving schedules of counselling sessions, receiving schedules of practical sessions, receiving grades and result-related information.

(continues)

APPENDIX 14 (continues)

Author(s) (Year)	Research purpose	Data collection method(s)	Duration	Participants	Main findings
Gu, Gu & Laffey (2010)	A set of design principles from both pedagogical and usability concerns was identified. A pilot system based on the design principles, was developed.	Heuristic walkthrough method		University students and employees	The usable learning products must be practical, micro and simple both for content and activity. The learning products delivered by mobile devices must meet the user's learning need. Users have high expectations. Multimedia is not necessarily desired but audio is preferred. It is more preferable to use simplified text with meaningful pictures.
Huang, Jeng & Huang (2009)	To design a mobile blogging system	Questionnaire	Learning activity: 2 months	College students (N=40=	The results revealed from the learning outcome were positive and encouraging. Students' learning attitude was enthusiastic. Students thought that the system was helpful and a convenient tool for acquiring more authentic context learning examples. It is important to but right technology into right pedagogic application with an appropriate pedagogic theory.
Hwang & Chang (2011)	The study proposed a formative assessment-based approach for improving the learning achievements of students in a mobile learning environment.	Pre-test & post-test, Questionnaire, Cognitive load survey	275 minutes total. Activity wherein mobile learning system was used 120min.	Two classes of fifth grade students of an elementary school. One class (29 students) was assigned to be the experimental group and the other (32 students) was the control group.	The results showed that the proposed approach not only promotes the students' learning interest and attitude, but also improves their learning achievement. The approach provided a more challenging learning environment that encouraged students to solve problems. The challenges during the learning process motivated the students to learn. Generalizations about students' motivation or attitude are difficult to make based on a short timeframe.

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APPENDIX 14 (continues)

Author(s) (Year)	Research purpose	Data collection method(s)	Duration	Participants	Main findings
Hwang et al. (2010)	To build a mobile learning environment with both physical and virtual resources.	Pre-test & post-test, Cognitive load questionnaire, Interviews	The interval between the two tests is two weeks.	Two classes of 6 grade students (51 students). One class was assigned to be the experimental group and other to be control group.	The results indicated that the students who received blended mobile learning instruction had better learning achievements and less cognitive load. PDAs provide a personalized learning scenario allowing students to learn according to their own schedule and to practice iteratively. The students showed greater interest and enjoyment in using PDAs to learn. The learning load of the students can be decreased if the learning system as well as the learning activity is appropriately designed.
Hwang, Shi, Chu (2011)	To design a concept map-oriented Mind tool for collaborative ubiquitous learning.	Pre-test & post-test, Questionnaire, Interviews	Experiment: 610 minutes	70 elementary school students (10 years old). Students were divided into three groups (experimental & control).	This approach enhanced learning motivation and improved the learning achievements of the students. Students will be benefitted more if they are situated in realistic learning environments.
Jacob & Issac (2007)	Brief investigation about the mobile learning benefits and an analysis of the student perceptions on mobile learning.	Questionnaire		Students (N=250)	Mobile learning is widely embraced by the student community. The majority of students supported the notion that the wireless networks increase the flexibility of access to resources in learning and that they could work independently. There was a significant statistical relationship between the attitude index and attitudes to new technology. There was no significant relationship between the attitude and gender.
Kalhoro et al. (2010)	To investigate the strengths of mobile learning application.	Open-ended and close-ended questionnaires		University students (N=100)	Students´ perception about m-learning: it is user-friendly, secure and reliable and it saves time. Students felt more personalized and content. M-learning is one of the brightest hopes to reduce the digital divide in Pakistan.

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APPENDIX 14 (continues)

Author(s) (Year)	Research purpose	Data collection method(s)	Duration	Participants	Main findings
Kim (2009)	To investigate the possible effects of various affordances for the handheld mobile learning model.	Interviews (formal and informal), Direct and indirect observations (diaries, documents, audio and video recordings, photos)	15-mont period	Over 250 migrant indigenous children (different ages 3-13) and about 20 parents from five villages, 9 local and regional representati ve, 4 government officials, 5 technology corporate leaders, and 6 support staff for the investigator contributed to the study	Interesting and joyful activities, listening, watching and reading short stories or animations with the mobile learning device provide substantial learning moments for the extremely marginalized migrant indigenous children. For the hardware design, a careful consideration is required because of numerous constraints in the context. Without cultural sensitization, learning contents may not make any sense.
Kumar et al. (2010)	To examine the feasibility of mobile learning in out-of-school settings in rural, underdevel oped areas.	Participant observations, Interviews, Log entries	26-week study	Field research: 45 children from 20 households. Deployment : 18 children from 15 households.	The mobile phones are a perfect vehicle for making educational opportunities accessible to rural children in places and times that are more convenient than formal schooling. There was a combination of social and technical barriers. Learning could be increased if barriers owning limited electricity and gender attitudes could be overcome. Mobile learning games created a shared context that encouraged the formation of new social ties across caste and village boundaries, which were less likely to have developed otherwise.
Law & So (2010)	To investigate QR codes in education	Student interviews		Two primary schools' students	QR codes in education are still in its infancy. Students found the activities interesting. QR codes have great potential in education.
Liu, Hu, Liu (2009)	Study investigate d learners´ preference for daily m-learning usage.	Questionnaire		65 students.	50.8 percent of the students had already used m-learning and more students stated that they would like to use m-learning in the future. Most students tend to use m-learning when situated in a stable environment, such as home, apartment or classroom. The highest technological restriction was low bandwidth followed by limited processor speed, lack of m-learning recourse and small screen size. Participants were willing to purchase m-learning courses when the quality of the course was good.

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APPENDIX 14 (continues)

Author(s) (Year)	Research purpose	Data collection method(s)	Duration	Participants	Main findings
Liu, Tan & Chu (2010)	To demonstrate the effectiveness of the proposed m-learning system	TAM questionnaire, Interviews	Experiment: four weeks	3 instructors and 20 undergraduate university students	Most students found the course interesting and most students found the system to be easy to use and useful for assisting learning. The system not only increased students' motivation to learn, but also enhanced their learning outcomes. 2D barcodes and handheld AR technologies are useful in providing context-aware, immersive experiences in English-learning activities.
Looi et al. (2010)	Study examined the learning effectiveness of the enacted mobilized science curriculum. The mobilized curriculum was designed to be student-centered, inquiry based and collaborative in nature.	Observations (video recordings, field notes), Student, parent and teacher interviews, Pre- & post-test, KWL table, Students artefacts, Students science examination scores before and after the mobilized activities	Mobilized science lessons: 21 weeks	Nine classes in primary grade 3 (360 students). One class randomly assigned to the experimental group and the others to control group.	The experimental class performed better as measured by traditional assessments. With mobilized lessons, students were found to learn science in personal, deep and engaging ways as well as developed positive attitudes towards mobile learning.
Lu & Viehland (2008)	The study determined the key factors influencing the behavioral intention for adoption of mobile learning.	Extended TAM questionnaire	Survey: seven weeks	180 student responses from six universities	The most important outcome of the study was to identify six key factors that influence the behavioral intention of users to adopt mobile learning; they are perceived the usefulness of mobile learning, perceived ease of use of mobile learning, an attitude toward using mobile learning, subjective norm, self-efficacy and perceived financial resources. The research did not measure actual acceptance and use of mobile learning; it only investigated the behavioral intention to adopt mobile learning.
Mierlus-Mazilu (2010)	The paper presents distance education using m-learning Objects.	Questionnaire, Final course points and grades, Activity of the students	The study was organized on the same course in two years. In the second year they had the learning objects available.	Four groups of 25 civil engineering students.	Wireless technologies enable learners to engage in collaborative and interactive learning activities. Using wireless technologies can be beneficial to all involved. Considerations that need to be taken into account are safety and security, and training and support considerations. mLearning objects are not the witchcraft. There should be more introductions and better integration of learning objects to encourage students to use them more frequently.

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APPENDIX 14 (continues)

Author(s) (Year)	Research purpose	Data collection method(s)	Duration	Participants	Main findings
Osawa et al. (2007)	To develop a support system for outdoor learning	Exploratory observation, Questionnaire	One day	45 university students were divided into four groups.	Many students enjoyed the system and considered it to be useful. 2D symbology tag system using a small and lightweight mobile phone was preferred. This type of system will enhance the motivation of students and improve the quality of outdoor education
Rebaque-Rivas, Gil-Rodrígue z & Manresa-Mallol (2010)	A user-centered design perspective to define mobile learning scenarios based on the daily routines of commuting students.	Online questionnaire, Graphic narrations, In-depth interviews, Observations		Four focus groups were conducted with 7 students from university	All of the students were enthusiastic about the possibilities offered by e-books for studying, as long as the devices had a series of characteristics specific for studying. The audio format was not seen as useful. The possibility for Internet access on their mobile phones for performing on-line learning activities was very highly rated. The definition of two mobile learning scenarios for commuting was created. These two scenarios can act as the basis for the design and development of new applications linked to m-learning.
Rogers et al. (2009)	Research is concerned with how mobile devices can be used to engender collaborativ e sense making activities during scientific tasks.	Observations, The logged data.	Two in situ studies were conducte d over a 12-month period.	6 environment al scientists, 18-24 students.	The findings show marked differences in the amount and type of sense making. The application was found to be effective for accessing contextually relevant information and data. For mobile devices to be effectively used to facilitate sense making depends on task demands and a workload, type of information and distribution of devices.
Rost & Holmquis t (2008)	Paper presents three add-ons for wikis and talks about the experience from having students using the tools live during the course.	User experiences (student reports), The logged data		Two student groups from university	Students reported that they found the mobile phone and application a very simple but powerful and helpful.

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APPENDIX 14 (continues)

Author(s) (Year)	Research purpose	Data collection method(s)	Duration	Participants	Main findings
Sánchez & Olivares (2011)	The paper presents the result obtained with the implementation of a series of learning activities based on Mobile serious games for the development of problem solving and collaborative skills	A structured, questionnaire, A scale for the perception of problem-solving skills, A scale for the perception of collaborative skills.	23 sessions distributed in a three-month period of time.	373 eight-grade students	The results showed that the intervention had an impact on collaboration and problem solving skills among the students who participated in the study. Developing games for learning opens up new possibilities for understanding how teaching and learning practices are mediated by technology and under what conditions those practices actually improve learning.
Shih et al. (2011)	To develop a context-aware u-learning environment	Student and teacher interviews, Questionnaire	Experiment: 2 weeks	Questionnaire: 34 fifth-grade students. Interviews: 8 randomly chosen students and 3 teachers	The u-learning approach can significantly and effectively increase students' positive learning attitudes. It is also capable of reducing the teaching load while enabling better control of class order. Students can get personal attention from PDAs. Students can more actively learn with their own preferred route and speed. Mobile devices allow students to compare the pre-designed learning materials with real live objects. Students provide their own perspectives. Although system development is an important factor, instructional design and learning evaluation are the most essential components for successful learning.

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APPENDIX 14 (continues)

Author(s) (Year)	Research purpose	Data collection method(s)	Duration	Participants	Main findings
Shih, Chuang & Hwang (2010)	Study presents a mobile exploration activity that guides elementary students to learn during a social science activity with digital support from mobile devices and wireless communications.	Pre-test & post-test, Questionnaire, Cognitive load questionnaire, Observations, Focus group, teacher interviews		33 fifth-grade students	Students were arranged to carry out investigations in the peace Temple of southern Taiwan with the inquiry-based mobile learning system. The goal was to evaluate the effectiveness of the approach. By using mobile devices, students can have a more customized learning pace and process, and can receive individual attention and learning guidance when they are distributed in the field. The results showed that the students' cognitive learning achievements made significant improvement, and their satisfaction level was high.
Shin, Jung & Chang (2012)	Study examines how TAM predict users' intentions to continue using QR codes	Individual in-depth interviews, Group interviews, TAM questionnaire	Survey: seven-month period	In-depth interviews: 10 randomly selected respondents from the university. Group interviews: 5 focus groups (4-6 individual in every group). Questionnaire: 370 responses	User intentions and behaviors are largely influenced by the perception of the quality of QR codes. Interactivity is a key behavioral antecedent to the use of QR codes.
So, Seow & Looi (2009)	To examine the potential of mobile computing and Web 2.0 technology to support knowledge building in formal and informal settings.	Student interviews, Student reflections, Student artifacts, Teacher diaries, Distant observations	One day event with several learning objectives.	Primary grade 4 students	Study suggested that with the tight coupling of mobile and Web 2.0 technologies from pedagogical perspectives, young learners can be engaged in participatory knowledge building process linking formal and informal learning experiences.

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APPENDIX 14 (continues)

Author(s) (Year)	Research purpose	Data collection method(s)	Duration	Participants	Main findings
Tan, Liu, Chang (2007)	To develop an environment of ubiquitous learning.	Pre-test & post-test, TAM questionnaire	Course: 16 weeks	Four teachers and 72 grade 5 students. Randomly assigned to the experimental group and the control group.	The proposed system significantly improves students' motivation and learning. The survey results indicated that most students thought that the system was easy to use and useful in learning.
Wang, Wu & Wang (2009)	The study investigated the determinants of m-learning acceptance and discovered if there exist either age or gender differences	UTAUT questionnaire		330 responses from five organizations	The results indicate that performance expectancy, effort expectancy, social influence, perceived playfulness, and self-management of learning were all significant determinants of behavioral intention to use m-learning. Age differences moderate the effects of effort expectancy and social influence on m-learning use intention and gender differences moderate the effects of social influence and self-management of learning on m-learning use intention.
Wu & Lai	Paper reports implementation and evaluation of a wireless handheld learning environment used to support a clinical nursing practicum course.	Students' reflective journals, Open-ended questionnaires, Students, instructor and nurses interviews, Observations (field journals)	A three-week practicum session.	6 female clinical nursing students, instructor	Both the instructor and the student benefited from using the PDA environment. The handhelds enhance learning and facilitated peer cooperation and interaction with the instructor. A major problem raised by the students using the PDA environment was the "connectedness". Several implementation issues arose during the course of study, which included the capacity of PDAs, internet resources, students' preconceptions about using PCs. Conceptions about PDAs were influenced by prior use of PCs.

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APPENDIX 14 (continues)

Author(s) (Year)	**Research purpose**	**Data collection method(s)**	**Duration**	**Participants**	**Main findings**
Xie, Zhu & Xia (2011)	Study investigates differences in need of mobile phone learning.	Questionnaire		200 students (196 questionnaires were valid).	Results showed that attitude of mobile phone learning, expectations, preferences in the form of resources and content, English majors have big different from non-English majors. Perceived usefulness, perceived ease of use, learner's self-monitoring ability is extremely significant impact on the attitude of mobile phone learning and a learner's own conditions significantly affect mobile phone learning attitude.
Yau & Joy (2009)	Paper presents the data analysis obtained from interview study, which showed that participants had different individual preferences and proposes a context-aware personalized m-learning application based on these preferences.	Interviews, Questionnaire, Diary entry sheets	Diary was kept two days.	32 university students	Proposed personalized m-learning application consist of three components 1) a learner profile for storing m-learning preferences, 2) a personalization mechanism, 3) a learning objects repository. This application has the potential for motivating learners to study in different m-learning environments as their individual m-learning requirements are taken into consideration.
Zhang et al. (2010)	Transforming primary three science lessons into a "mobilized" curriculum for a classroom context	Observations by researchers and the class teacher, Interviews, Student artifacts (e.g., KWL files), Development sessions, Year-end exam results	Three science lessons	One class of 39 students was assigned to be the experimental group.	The smartphone was an enabler to stimulate the transformation of teaching and learning. There were some positive changes in teacher teaching and student learning and their attitudes towards using mobile technologies for learning purposes. Students were very engaged in the inquiry tasks.

APPENDIX 15: THE ANALYSIS FRAME OF THE TEACHER INTERVIEWS

Aspect	**Specifically under observation**
1. Background information	Teaching experience Previous mobile learning experiences
2. Context, Time & Place	What? Where? When? How?
3. Device Aspect	Ease-of-use Technical problems during the experiment
4. Learner Aspect	Feasibility Learner attitudes Learner motivation
5. Social Aspect	Possible interactions Possible collaboration
6. Mobile Learning experiment	Opportunities Challenges Successes Failures Integration & pedagogy Experiences Attitudes Willingness to adopt a mobile learning approach
7. Other emerging aspects	

APPENDIX 16: THE ANALYSIS FRAME OF THE STUDENT SURVEYS

Aspect	**Specifically under observation**
1. Background information	Age Gender Previous mobile usage experiences Previous mobile learning experiences
2. Learning experience	I would like to use the mobile application again I prefer traditional teaching and learning methods The mobile learning activities were inspiring and motivating way to learn I learned some new things with the mobile application An overall assessment of the session
3. Device Aspect	Ease-of-use I needed help with the mobile application I needed to learn many new things before I was able to use the application The phone and application always functioned as I expected
4. Other emerging aspects	

APPENDIX 17: THE ANALYSIS FRAME OF THE ONLINE SURVEY

Aspect	Specifically under observation
1. Background information	**Gender** (multiple-choice: male-female) **Age** (multiple-choice: > 25 years, 25-29, 30-39, 40-49, 50-59, < 60 years) **Home county** (multiple-choice: Southern Finland, Western Finland, Province of Oulu, Province of Eastern Finland, Province of Lapland, Åland) **Teaching subject** (open-ended) **Teaching years** (multiple-choice: less than one year, less than 5 years, 6-10 years, 11-20 years, more than 20 years) *NB: The survey respondents' background information was set against information about the population by OECD (2013) and Finnish National Board of Education (Opetushallitus 2014)*
2. Mobile device utilization	**How often you have utilized mobile device as part of your teaching practices?(**multiple-choice: daily, weekly, monthly, less frequently, I have not used) **Why you began to utilize mobile devices as part of your teaching practices?** (open-ended; inductive category development of reasons why teacher had begun to utilize mobile devices)
3. Teacher's competencies	**Are you willing to use ICT as a part of your teaching practices?** (multiple-choice: yes-no) **Do you think that you have sufficient ICT skills?** (multiple-choice: yes-no) **Do you think that the mobile device integration to classroom is easy?** (multiple-choice: yes-no) and **give some reasons why or why not?** (open-ended; inductive category development of reasons why integration has been easy/hard)
4. Mobile learning activity	**Give an example of one of your mobile learning activities** (open-ended; data were categorized by mobile learning aspects: learner, device and social aspects, context, pedagogy, other emerging aspects; data were categorized by Puentedura's (2009 and Norrena et al. (2011) frameworks; inductive category development of reasons why all mobile learning potential is not utilized)
5. Other perspectives	**What else would you like to say about mobile learning?** (open-ended; data were categorized by mobile learning aspects: social aspect, learner aspect, device aspect, ICT integration strategies, curriculum, teacher's competencies, other emerging aspects)