Understanding Scalability and Sustainability in Mobile Learning: A Systems Development Framework
Understanding Scalability and Sustainability in Mobile Learning: A Systems Development Framework

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Abstract


The rapid development of mobile technologies combined with access to content almost everywhere and every time allows people to experience new situations regarding learning in a wide variety of situations. Mobile learning brings the promise of learning “on the move” by allowing learners to take control over time and space, thus making learning “more natural”. The field of mobile learning has rapidly evolved in the last ten years and many initiatives have been conducted worldwide. However, research results indicate that few of these efforts have produced any lasting outcomes. It is evident that these initiatives are faced with inherently complex settings and that the outcomes might not live up to their promises; will not be adopted and, hence, will not become sustainable.

Many of the complex issues faced by mobile learning initiatives are similar to those faced by the development of information systems. This latest statement suggests that an improved development practice might hold one piece of the key to sustainable mobile learning. The aim of the research presented in this thesis is to investigate the relation between information systems development practice and mobile learning development; and if methods and models originated within information systems development can be used to strengthen mobile learning initiatives. In order to investigate this relation, this thesis studies several mobile learning initiatives with a particular focus on how and why development and research was initiated and conducted. Concepts found in mobile learning practices are strengthened by providing a theoretical perspective with roots in information systems development. The outcomes of the studies presented in this thesis indicate that the development practice of mobile learning initiatives can be redefined in order to achieve more sustainable results.

The core of this thesis consists of eight peer-reviewed scientific publications that have been presented at different international conferences. Five of the papers explore the field of mobile learning and its practice while the other three publications present the central ideas that serve as the basis for the proposed framework, how it has been developed, and the motivations behind its creation.

The main contribution of this thesis is a novel development framework aimed at researchers and practitioners in the field of mobile learning. The framework defines the life-cycle of a mobile learning initiative and identifies the importance of emphasizing the concepts of scalability and sustainability during the development process. This may be a way to reduce the complexity inherent to mobile learning and its settings, and a means to improve the outcomes of coming mobile learning initiatives in terms of long lasting usable results.

Keywords: information systems, mobile learning, scalability, sustainability, systems development
To Dad
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Anna C. Wingkvist
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Chapter 1

Introduction

In 1977, Alan Kay and colleagues at Xerox PARC envisioned a mobile electronic device called “Dynabook” (Kay and Goldberg, 1977). The idea was to develop a small portable computer in the shape of a book aimed to give children access to interactive software applications and digital media. It is only recently that information technologies have finally reached a level of maturity that allows for this vision to be crystallized. Many of our everyday intellectual activities are now supported by mobile devices. Learning, as a particular instance of those activities can be now enhanced by multimedia-equipped mobile phones, personal digital assistants (PDAs), pen tablet computers, and so on. The advance of information technologies and their adoption and integration into a wide variety of educational settings have allowed for the field of mobile learning to grow to a set of significant activities in schools, work-places, museums, cities, and rural areas around the world, as acknowledged by Sharples et al. (2009). The focus on mobile learning has increased in recent years, and it has lead to many research endeavors aiming at designing, developing and deploying mobile technologies to support learning, according to Taylor et al. (2006).

According to Kukulska-Hulme and Traxler (2005), the prevalent understanding of mobile learning is that it is learning on the move, often enabling the learner to take control over time and place, making it more spontaneous and personal. Naismith et al. (2004) suggest that using the time when a person is mobile is a way to tap in to a resource that may not have been used optimally, or not used at all before. Sharples (2000) states that a learner does not have to be on the move per se to experience mobile learning; just requiring information without the ability to access static learning resources (e.g., libraries, desktop computers, textbooks, etc.) suffice. This view is also transparent in the definition of mobile learning provided by O’Malley et al. (2003) stated as follows: “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 learning opportunities offered by mobile technologies” (p. 6).

Mobile learning as an emerging research field can be characterized by constant technological changes, novel pedagogical/educational approaches, and collaborative endeavors. These initiatives (as they will be called from now on in this thesis) are faced with, and need to deal with a set of problems to
meet the challenges presented when establishing a new field of research. The majority of these initiatives up to date have been initiated by researchers (i.e., the core team) and the focus of these efforts has been mostly on exploring novel uses of mobile technologies and their potential to support learning. However, these research efforts involved also other stakeholders beyond members of the research community namely; students, teachers, system architects, system developers, administrative staff, and hardware vendors just to mention a number of those. In the context of this thesis these stakeholders are called practitioners and they are also regarded as part of the extended team.

Järvelä et al. (2007) remark that only a few studies give detailed arguments as to what these new opportunities are, in terms of learning interactions and collaboration and what are the exact processes that mobile tools can scaffold. Hence, to this day, few of the mobile learning initiatives have resulted in the implementation of actual learning aids that are in wide use, as observed by Traxler (2007). Traxler (2007) also claims that the very nature of mobile learning “is essentially personal, contextual, and situated” (p. 1) meaning that it is particularly “noisy” and problematic when it comes to its definition and assessment. The latest raises a concern related to the large scale and sustainable implementation and adoption of mobile learning. While a big number of research initiatives have been so far more technology-driven, there is a need to understand the impact of the technology and its implementation in relation to the overall context and to comprehend and share the reasons for (partial) success or failure stories.

Most of the publications at large report very little on what “went wrong”. However, there are a number of cases in which researchers have identified which problems may affect the expected results. Yeh et al. (2006) provide one example of an initiative where the technology simply was not suited for the actual use. They reported that their ButterflyNet, a mobile capture and access system for field biology research students, based on the use of smartphones and cameras, had trouble recognizing the visual tags given to specific specimens due to tall grass. Nature, which was an obvious setting for the trial, was a limiting factor, as the grass occluded parts of the barcode that was supposed to be used to identify and coordinate the digital photos and notes taken at the time.

Another example in this direction is provided from Boticki et al. (2009), who designed a system called MILE (Mobile and Interactive Learning Environment) to support university teachers with instant feedback during lectures, and students to entice interaction and collaboration, through the use of different modules available to mobile devices (e.g., schedule, whiteboard, notebook, survey, and guide). Spite of the flexible solutions offered to the learners, MILE required a lot from the students’ ability to multitask since, for example, listening to a lecture, following a displayed presentation, answering surveys, taking notes, and exchanging them with others, all at the same time is challenging even for the most skillful person.

The third example is based on the outcomes from the MyArtSpace project.
The goal of this initiative was directed to support students on their field trips to museums with a platform enabling them to use a mobile phone and record their visit through digital notes, photos, and sound and have access to them later on their return to the classroom. The museums were responsible for handling and administrating the mobile devices and it turned out that the curators at the museums did not want to maintain, charge, or instruct the visiting students on their use. Besides, the question of who will pay for the communication (over the network) had not been considered as mentioned by Sharples et al. (2007), which can also compromise the outcome.

In order to tackle some of these difficulties, Sharples et al. (2009) suggest that the design of mobile learning should be driven by specific learning objectives and that the use of (mobile) technology should not be the target but rather a means to enable and facilitate learning activities. In fact, Taylor (2004) claims that the field of mobile learning must develop a thorough understanding of:

- the learning opportunities presented by the new mobile technology,
- its (potential) impact on the way people perform learning tasks,
- its (potential) impact on human social processes and interactions, and
- how these in turn are changed or modified by the technology.

The rapid development of mobile technologies combined with access to contents almost anywhere and at any time allows people to experience new situations regarding learning in a wide variety of situations. Mobile learning brings the promise of learning “on the move” by allowing learners to take control over time and space, thus making learning “more natural”. The field of mobile learning has rapidly evolved in the last ten years and many initiatives have been conducted worldwide. However, research results indicate that few of these efforts have produced any lasting outcomes.

As pointed out earlier in this section, the development and results in several mobile learning initiatives have been affected by technical limitations, when environmental impacts such as weather or vegetation made them difficult or impossible to use or by an overestimation of learners’ abilities to handle the technology and hence the tasks required of them, or by ending up with technical solutions that do not fit the intended organization’s infrastructure.

These issues indeed have an influence and affect the development, implementation and adoption of a mobile learning initiative by making it more complex, more costly, taking longer time, or not achieving the expected outcomes making this effort unsuitable for the learning purpose or setting, it was conceived for. Traxler and Kukulska-Hulme (2005) refer to these problems as sustainability issues. They further state that often the initiatives produce outcomes of a questionable value, and ones that may not scale up outside the time and budget frame of a set project. Quite notably, it is evident that initiatives in mobile learning are faced with inherently complex
settings and that the outcomes might not live up to their promises, will not be adopted and, hence, will not become sustainable. (A more detailed discussion on scalability and sustainability is provided in Chapter 5.)

Since the field of mobile learning is multidisciplinary, the development of mobile learning may involve researchers that span across disciplines such as Computer Science, Information Systems, Pedagogy, Project Management, and so on. Actually, many of the complex issues faced by mobile learning initiatives are similar to those faced by the development of information systems. This suggests that an improved development practice might hold one piece of the puzzle to more sustainable results in mobile learning.

For example, from an information systems development perspective it can be useful to regard an information system consisting of components that result from the interplay between technical artifacts (i.e., IT artifact) and people. One example, from Bostrom and Heinen (1977), building on the socio-technical school of thinking (from the Travistock Institute) acknowledges these as two separate systems, the social and the technical, respectively, and focuses explicitly on the interactions between them. (For more on these issues see Chapter 2 and Chapter 5.)

While mobile learning can be analyzed and understood from a socio-technical systems perspective, it is still unclear if this notion is enough to capture all the components and interactions. For example, the claims made by Taylor (2004) stress the importance of knowing about how a learning task is performed and the impact on the different social processes. The learning tasks are, naturally, not explicitly part of the definition of socio-technical systems. They can be fitted into the socio-technical systems terminology), for example by considering pedagogical theories as an extension to either the social or the technical system, but it is not clear if this is viable and a good strategy. This specific concern is one of the driving forces that helped to identify the research questions that guided the research presented in this thesis.

1.1 Problem definition and motivation

As previously mentioned, lasting and sustainable outcomes in the field of mobile learning are hard to come by. The results so far have been at best inconclusive. Part of the difficulties is that these initiatives face being in inherently complex settings including the diversity of team members who are supposed to communicate and cooperate together. Overall, the promise and the drive behind these initiatives have the best intentions. They are on the quest to utilize (mobile) technology to enhance and improve learning experiences.

Actually, many of the initiatives seem to fall short of what was expected of them. These initiatives often propagate technology not suited for the actual use in the settings, not being able to acknowledge and reserve support from key personal at target organizations, little to no ambition reaching large-
scale audience in terms of users, or orchestrate learning scenarios that simple
do not make sense — not being able tie the location, the learning experience,
and the task together.

With respect to these difficulties, there is definitely a need to go back
to the drawing board. The blue prints, from the author’s point of view,
constitute the core in the development practices that should guide these
initiatives and how it can help to improve the outcomes of these efforts. An
improved understanding of development practices and how this is perceived
among the team members can be one means to improve the outcome of
these initiatives.

Consequently, the aim of the research presented in this thesis is to inves-
tigate the relation between information systems development practice and
mobile learning development and whether research and practices originated
within information systems development research can be used to strengthen
mobile learning initiatives. In order to investigate this relation this thesis
studies several mobile learning initiatives with a particular focus on how
and why development and research were initiated and conducted.

Thus, concepts found in mobile learning practices are strengthened by
providing a theoretical perspective with roots in information systems devel-
oment. The outcomes of the studies presented in this thesis indicate that
the development practices of mobile learning initiatives can be redefined in
order to achieve more lasting results.

1.2 Research Questions

Based on the complexity inherent in mobile learning and its settings, the
hypothesis of this thesis is that the development practices of mobile learning
initiatives can be improved and be a means to enhance the outcomes of
coming mobile learning initiatives in terms of long-lasting usable results.

In order to enhance the understanding and aid the development process,
the following research questions have been identified:

1. What are the current research approaches and practices in the field of
   mobile learning?
2. How are practices in information systems development and mobile
   learning related?
3. How can knowledge (research and practice) from information systems
   development support mobile learning?
4. How can the results of this research be brought back to the researchers
   and practitioners in the mobile learning community?

The first research question aims to investigate the state of the art of mo-
bile learning with a focus on research and development; understanding how
and why research is conducted, and what role the development practices
play. This question further aims to strengthen the hypothesis that a better
understanding of the field will improve the sustainability of these initiatives and will have also positive implications when it comes to development practices.

The second research question focuses on understanding how specific aspects of mobile learning are related to the field of information systems development. As discussed previously, information systems can be considered as socio-technical systems. While mobile learning certainly can be described as consisting of both a technical and a social system, the question is whether this is a sufficient and suitable description.

There are social and technical systems present in mobile learning, and the third research question revolves around how useful research and practices in the field of information systems development are and how easily they can be adapted to understand and improve mobile learning development and practices.

The fourth and final research question looks at how the results of the research conducted in this thesis are best brought back to the mobile learning community (currently populated by researchers). There are several means to transfer research results, all of which have their benefits and drawbacks. However, the goal of this work is to present the results in a way that is also meaningful to mobile learning researchers and practitioners.

1.3 Limitations

This thesis is concerned only with the development practices of mobile learning drawing on knowledge on development practices arising from the field of information systems. The development of mobile learning requires indeed knowledge on pedagogy (e.g., learning and cognition theories), mobile technologies and software, and social communication, however, these areas not explicitly addressed in this research. Hence, the discussion of how mobile learning can improve learning or for example which pedagogic theories are best suited for certain initiatives is left to other researchers to decide. The development practices discussed in this thesis only points to the need for such considerations.

1.4 Organization of the Thesis

The rest of this thesis is organized as follows. Chapter 2 introduces the theoretical foundations of this work. This is followed by a discussion on methodological considerations presented in Chapter 3. This chapter presents the overall methodological view of the thesis, as well as the methods used throughout the research. Chapter 4 presents an overview of the appended publications summarizing the research contributions of each one. Chapter 5 relates the appended publications to the research questions posed in Chapter 1. Each question is discussed with a focus on how the appended publications
1.4 Organization of the Thesis

together provide a deeper insight into the question and its answer. Chapter 6 concludes this thesis by providing a summary of the main contributions as well as future directions of research. The last eight chapters contain the appended publications.
Chapter 2

Theoretical Foundation

This chapter presents the theoretical foundations of this thesis. The aim of the research is to investigate and improve the development practice of initiatives in the field of mobile learning. The point of departure, given the author’s background and main area of expertise, is placed within information systems development.

The chapter begins by discussing how computer-based systems are developed. The main purpose of this discussion is to establish the terminology used within this thesis and why it was chosen. The chapter continues with an overview into information systems development and the notion of socio-technical system and the different perspectives it entail. This presentation is not intended to provide a complete picture of information systems development nor its history.

As previously mentioned, mobile learning is the field of inquiry, and the chapter also contains a discussion on the ongoing effort to establish theories within this emerging research field. This discussion is intended to show how the field moves from a technological focus to addressing more the learning activities and the social context as important considerations.

In order to improve the development practice, there is a need to understand the problem domain and reason about it. A useful aid in understanding is to create conceptual models and in turn frameworks that capture phenomena in reality. Describing reality and making theoretical contributions is always done with a certain degree of abstraction. Hence, this chapter also includes a discussion on conceptual modeling, which was used as an approach in formulating the framework that is the main contribution of this thesis.

The chapter ends with a brief discussion of the similarities of the point of departure and the field of inquiry. This discussion is the motivation behind the second research question and it is continued in Chapter 5.

2.1 Development of Computer-Based Systems

Computers are ubiquitous in todays organizations. Hirschheim et al. (1995) point out that computer-based systems have moved from supporting back office (such as payroll) to enter into all functions in respect to the entire organization. In the beginning the core work revolved on the development
of computer-based systems. These were programmed rather than designed, and the development was technology focused and carried out by experts. These experts often followed systematic practices, to help deal with the complexity, but such practices were invented when needed and closely related to the technology at hand.

Programming practices and techniques that worked well were re-used, and adapted as needed, basically forming sets of guidelines. But, with each team or even person using their own practice, it was difficult to deal with the development in a systematic way and communicating it to others. In order to improve the situation, a great deal of research efforts was put into reasoning about and describing the development process to provide a theoretical platform to form the basis of work and communication.

This led to many important discoveries, such as the distinction between logical and physical design, organizational development, risk analysis, stakeholder inclusion, etc. It also resulted in the formulation of life-cycle models that describe the systems development, for example, the Systems Development Life Cycle (SDLC) (Sommerville, 2006). Such life-cycle models describe the development of an information system as a a set of stages, to plan, manage, control, and evaluate the same (Avison and Fitzgerald, 2006). The stages of the SDLC can be described as:

- feasibility study,
- system investigation,
- systems analysis,
- systems design,
- implementation, and
- review and maintenance.

New methodologies were formulated as an attempt to describe information systems development practices. A information systems development methodology, according to Hirschheim et al. (1995), can be described as a collection of methods and tools that help the system developers in their efforts. A method is a way to perform a particular activity during the development. A method often involves the use of one or more tools. Avison and Fitzgerald (2006) remark that an information systems methodology also has a conceptualization of a life-cycle.

However, an information systems development methodology is more than a collection of methods. It is based on a philosophical view, and includes beliefs and values. These guide both the overall development practices and what is considered a good solution. A philosophy might be that an information system that is, for example, the easiest to implement, cheapest to run, or liked by the stakeholders is preferable and regarded a good solution (Avison and Fitzgerald, 2006).

There exist a large number of different information systems development methodologies, and they differ in the collection of methods and tools or in
2.2 Information Systems Development

terms of the philosophical views. Two different methodologies might share methods and tools but differ in their philosophical view. This makes certain methodologies more suitable for some problems, people, or organizations than others.

One example of an information systems development methodology is the Rational Unified Process (RUP) (Kruchten, 2000). RUP uses the Unified Modeling Language (UML), which is a tool, to describe use-cases, which is a method. One belief of RUP is that the development practices should be iterative and incremental.

Hence, a methodology provides a step by step description of how a system should be developed, using the stages of the life-cycle, and the methods, and tools included. Although, a large number of stages, methods, and tools might make a methodology a blunt instrument to use in some cases, or difficult to master according to Avison et al. (1998). Avison and Fitzgerald (2006) state that a framework is similar to a methodology but less restricted and rather than enforcing a strict step-by-step order it leaves room to choose what best suit the situations, people, or organizations. A framework can provide the overarching structure of the development practices and be a platform for work and communication.

The use of the three concepts, methodology, method, and framework, is not uncontroversial. Methodology can in many cases refer to both a collection of methods and the study of methods. Cronholm and Ågerfalk (1999) present a study of the use of the concepts of methodology and method within information systems research and presents a conceptual model to help define the concepts. In this thesis, however, having mobile learning as the field of inquiry is compelled to use the concepts in the way that is familiar to this community.

2.2 Information Systems Development

The introduction of information systems development methodologies, as discussed in Section 2.1 advanced the development practice within the field of information systems development greatly. However, there were still issues with the end products (i.e., the information systems) produced. Many of the information systems were technically sophisticated, but lacking in terms of connecting to the social work environment. The development methodologies often regarded information systems as solely computer-based systems and their introduction as a technological activity.

Smithson and Hirschheim (1998) state that the introduction of an information system normally has social, organizational, and human implications and is never just a technological activity. The information system represents more than just computers and software. The users and the organizations they are part of both affect and are affected by the information system, putting focus on issues such as usability, policy, ethics, and so forth. Smithson and Hirschheim (1998) further suggest that there are few com-
mon or widespread organizational interventions so poorly understood and surrounded by such exaggerated expectations as information technology.

Hence the approach to regard information system in terms of a socio-technical system emerged, acknowledging it as a system that involves complex interactions between people, machines, and the work environment, according to Emery and Trist (1960). Another example, also building on the socio-technical school of thinking acknowledges these as two separate systems, the social and the technical, respectively, and focuses explicitly on the interactions between them (Bostrom and Heinen, 1977). Badham et al. (2001) state that there are five key features of a socio-technical system are that:

- the system has interdependent parts,
- the system adapts to and pursues goals in external environments,
- the system has an internal environment comprising separate but interdependent technical and social sub-systems,
- the goals of the system can be achieved by multiple means, and
- the system performance relies on the joint optimization of the technical and social sub-systems.

Socio-Technical Systems Design (STSD) approaches take the people, machines, and context into consideration when developing systems. There are several such approaches that often exist on a more abstract level than the methodologies discussed in Section 2.1. One such example is the ten principles provided by Cherns (1987). The principles are formulated on a level relating to social and organizational aspects. While these principles point out important issues, they provide little (practical) guidance for someone developing an information system. These are more to be seen as a checklist. For example, one principle is labeled “Incompleteness”, since redesign is continuous and is the function of self-regulating teams, emphasizing that work group design is never complete.

There are, however, some approaches to STSD that can be considered as systems development methodologies. One such example is ETHICS (Mumford, 1983) where the social and technical systems are designed in parallel to allow them to intertwine and to help optimize their interaction. Another key aspect of ETHICS is active end-user participation in the design. Another example is the Soft Systems Methodology (SSM) (Checkland, 1999a), which was developed as a move from thinking about systems in “hard” engineering terms. SSM does not divide a system into technical and social (sub-)systems but rather view the system as being composed of logically linked activities. A key feature of SSM is the focus to develop an understanding of a problematic situation. In this sense, SSM is essentially an analytical approach.

While there is a general consensus that an information system should be considered within its social context, and that the problem addressed
by STSD is important, the approaches have failed to make a significant impact on how systems are developed (e.g., Mumford (2006)). A problem that makes the adoption of STSD more difficult is the term socio-technical system. The term was coined by researchers at the Travistock Institute with a specific meaning. It is also often closely linked to the ETHICS methodology. However, the term has been adopted by many researchers in different fields, often using their own interpretation. A socio-technical system often refers to the social and the technical system (as the name imply), while the interaction between these are disregarded.

Another source of problems with STSD seems to be that compared to the technical, the social appears more complex and difficult to make sense of, hence less explored and understood. For example, several technical characteristics, such as response time or failure rate, can be defined and measured for an IT artifact, while ergonomics and usability are perceived more challenging to measure. Majchrzak and Borys (2001) claim that the existing socio-technical systems theories are not specific enough to allow for empirical testing. Further, it can be difficult to define criteria to measure the social elements of the system. Land (2000) discusses how to, for example, measure job satisfaction, but also point the fact that the success is measured by various stakeholders and they have different viewpoints and value systems. In a sense, the technical element measures can be considered objective, while the social are more subjective often leading to difficulties comparing and making choices.

There is also a concern to find the right abstraction level. The information systems development methodologies established life-cycle models as well as methods to model and reason about the information system. From this viewpoint, it might be tempting to divide a socio-technical system into a social and a technical part, and then continue to decompose these two separately. This in turn might result in a different emphasis on the two parts, and focus often falls on the technical. Another concern regarding the abstraction level was raised by Hollnagel (1998) who points to an overemphasis of the context of a socio-technical system (i.e., the organization) at the expense of the individual.

In a sense, the complexity of the social dimensions in this respect and the difficulty to find reasonable abstraction levels to handle these, attributed to the identity crisis noticeable in information systems research according to Benbasat and Zmud (2003) and Orlikowski and Iacono (2001). For example, Orlikowski and Iacono (2001) argue, based on a review of articles published in information systems research between 1990 and 1999, that a significant number of these either focus on the context, some capability of the computer-based system, or a specific variable assigned to the implementation or use of the technology. In many cases the computer-based system is implicit in the research, i.e., assumed to work in the background. Orlikowski and Iacono (2001) conclude that “we will need to stop taking IT artifacts for granted and begin to take them seriously enough to theorize about them” (p. 131), and propose five premises as a basis for further theorizing. In short,
they argue that:

- IT artifacts are always value based, since they are designed and used by people with different interests, values, and assumptions.
- IT artifacts are always embedded in a historical and cultural context.
- IT artifacts are usually made up of several components, and generic terms such as the Internet and “the Technology” should generally be avoided.
- IT artifacts are not fixed and independent, but co-evolve with the workpractice in which they are embedded.
- IT artifacts are subject to changes in technology.

Benbasat and Zmud (2003) also point to the need to theorize the IT artifact, and propose what should be included and excluded for the field of information systems research. They state that it is necessary to understand the role of the IT artifact in a social context, and which aspects of both the IT artifact and the social context that should be left for other fields to investigate. Benbasat and Zmud (2003) assume that the IT artifact exists within a social context and they focus on three core information system properties: the IT artifact, its use, and its impact. This is in line with the socio-technical system view that the technology has social effects. This correlate with Lee and Baskerville (2003), who state that an information system is emerging, in a broad sense, from the interaction between people, practices, and technology.

2.3 Mobile Learning Development

In order to understand mobile learning and the issues initiatives faces there is a need to understand how the field evolved. The idea to use information technology to support learning is not new. The term e-learning is often used to describe the use of computers in education, but the term itself is ambiguous and can refer to many different aspects of technology-supported learning. A common meaning of the term is web-based distance education. Almost all definitions of the word have a strong focus on technology, and much of the research into the field of e-learning has focused on the development and use of information technology.

An early definition of mobile learning referred to it as e-learning using mobile devices stating “it’s e-learning through mobile computational devices: Palms, Windows CE machines, even your digital cell phone” (p. 1) to cite Quinn (2000). This definition carries over the e-learning focus on technology to mobile learning, and considers it as a means to access content, rather than as a way to integrate learning as a part of an increasingly mobile style of life.

The concept of mobility in mobile learning is larger than the mobility of devices. Sharples et al. (2009) define the mobility in mobile learning as including:

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• the physical space,
• technology,
• the conceptual space,
• the social space, and
• time.

Learning can (and does) happen at any time and at any place. Sometimes the location or time is important to learning (such as a museum visit) and sometimes it is just a setting (such as the gym). Research in the field of mobile learning can be considered the investigation of how these aspects of mobility assisted by technology can help learners to receive and gain new knowledge. The view of mobility in mobile learning is in many ways similar to studies of the role of mobility in information systems, for example, as investigated by Kakihara and Sørensen (2002).

The new focus of mobile learning has resulted in a call for a theory of mobile learning, that incorporate how mobile learning differs from other kinds of learning. Sharples et al. (2005) define five criteria and suggest that any theory of mobile learning should be tested against these questions:

• is it significantly different from 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?

A great deal of effort has been put into providing such a theoretical basis for mobile learning. The rest of this section highlights a number of the theories produced.

Laouris and Eteokleous (2005) rest on a mathematical notation when they provide what they consider an educationally relevant definition of mobile learning. The mathematical notation is used to describe relations and dependencies between elements, e.g., content, IT, learning environment. In terms of intent they try to describe all the relevant parts of mobile learning in an abstract but structured and systematically complete way.

They propose the following formulation for the definition:

$$MLearn = f\{t, s, LE, c, IT, MM, m\}$$

Where, $t =$ time, $s =$ space, $LE =$ learning environment, $c =$ content, $IT =$ information technology, $MM =$ mental, and $m =$ method. These definitions are covering technical, methodological, pedagogical, social, and philosophical dimensions. The concepts are then described as relations and dependencies, using functions. For example, the Information Technology
resources available are described as functionally dependent on the learning space, \( IT = f\{s\} \). The attempt is done to address the complexity of mobile learning and is a way to visualize in greater detail the interrelation between certain elements.

Sharples (2005) proposes that mobile learning is defined as the processes of coming to know through conversations across multiple contexts amongst people and personal interactive technologies. A central claim of this definition is the importance of conversation. Sharples rest upon work by Dewey and Friere, and claim that conversation is the driving process of learning. To better understand and define the conversations and the role they play in the process of learning, Sharples turn to Conversation Theory (Pask, 1976). Conversation theory has been used for similar purposes, for example by Sharples (2003) and Laurillard (2002). Technology provides the means for or enriches conversations. Every human involved in a conversation has a physical location, a context. This context has to be negotiated by the parties of a conversations, since mobile learning allows for the learners to experience different contexts. The learning is characterized as a process of coming to know through conversation across continually reconstructed contexts.

In order to better understand the learning activities and the context, Sharples et al. (2005) suggest to analyze mobile learning as a cultural-historical activity system (Engeström, 1987) mediated by tools. They further suggest that the expanded activity model (Engeström, 1987) should be viewed from two perspectives (i.e., have two layers), a technical and a semiotic, in order to better explain the role of technology in learning. Similarly, they suggest that the cultural Rules, Community, and Division of Labor should be renamed Control, Context, and Communication to better support the communication between educational theorists and technology developers.

The theory developed by Sharples et al. (2005) is used (as an input) to formulate a systems development methodology for mobile learning by Taylor et al. (2006). It is based on the socio-cognitive engineering methodology (Sharples et al., 2002), which focus on the analysis of interactions between people and computer-based technology. Socio-cognitive engineering is user-centered but also acknowledge that users are not always reliable informants (Sharples et al., 2002). In order to deal with this, the methodology suggests to both carry out field studies to study the users and how they interact with technology as well as to take an analytical stance and for example study the cognitive processes and social interactions to form a theory of use. These two together form a task model that is used as input to the iterative development practices of socio-cognitive engineering and Taylor et al. (2006) provide such a task model for mobile learning.

Taylor (2004) presents a conceptual model where the overall aim is to evaluate the pedagogical effectiveness of mobile learning and thus ensure that it is sound. She is starting from a technical standpoint, entering into usability aspects, and continuing with pedagogic issues and socio-pedagogical per-
2.4 Conceptual Modeling

The systems approach is a central conception in information systems research and practices (e.g., Checkland and Holwell (1998)). The systems approach would treat the IT artifact, its users, and any relevant parts of the organization as one whole integrated purposeful system. The system approach to develop information systems takes its roots from early management theory, and is based on Bertalanffy’s General System Theory (mentioned in Avison and Wood-Harper (1991)), who formalized the system concept. Systems are defined as sets of interrelated parts that have emergent properties, which cannot be identified in any of the parts when viewed individually.

From the perspective of a systems approach, it must be understood that it is a way of thinking, as pointed out by Checkland (1999a). In applying this thinking, the researcher tries to view the system holistically in a particular environment, always keeping in mind what the system as a whole is suppose to achieve. So, in utilizing the system approach the researcher would treat the information technology, its users, and the relevant organization as one whole purposeful and integrated system but also acknowledging it as an open system existing in an environment(Hasan, 1999). As one of the founding advocates of the systems approach, Churchman (1971) considers the goal of a researcher to bridge philosophical reflection into the world of practice.

Conceptual models and frameworks are created in an attempt to capture a certain degree of abstraction. It contains a unification or synthesis and also triggers the ability to understand the magnitude of issues involved. The conceptual model is there to correspond to the actual research. This is to understand better the different findings throughout the research and put them into context. In accordance with Robinson (2006), a framework is the abstraction of a real or proposed system. Thus, in order to develop a conceptual model, some level of simplification of reality is needed. A conceptual model can be seen as a set of concepts that stand in relation to each
other to explain a phenomenon in the real world. This entails a presentation of the conceptual model, often consisting of an explanation interlinking text, figures, and tables, which all are descriptive and informative in character, to match the intended audience. Conceptual models can be useful as a thinking tool, as it is bringing together practice, theory, and research in an attempt to give greater understanding of the complexity involved.

In the academic field, researchers have employed concepts from other areas to make progress in “understanding” a phenomenon in the real world. However, their conceptual models are often not shaped to be understood by practitioners, but have the target group of other researchers instead. There seem to be a wide gap between some conceptual models and practice. This is something frameworks normally are trying to bridge by merging the academic theoretical thinking while also providing a tangible conceptual model for practitioners to work from.

2.5 Summary

This chapter discusses how both information systems development and mobile learning moved from a technical focus to include social dimensions in an attempt to provide theoretical contributions that better captures how the IT artifact is perceived and used. Information systems development acknowledged the socio-technical nature of an information system early on. This notion was later adopted by other related research fields, such as mobile learning, and applied to understand how (computer-based) systems are seen in relation to users.

Even if both mobile learning and information systems development research still struggle to describe the interaction between people, practices, and technology, there is a major difference. Information systems development established information systems development methodologies that represent a sound approach to development practices. This sound approach has lead to information systems that are sustainable, meaning present and persistent in every day life of people and constituting the backbone of organizations. While a number of theoretical contributions to handle the socio-technical nature of mobile learning exist, mobile learning has yet to produce initiatives (originating from the research community) with any lasting outcomes. There is a lack of conceptual modeling and in turn frameworks adjusted to the interplay between researchers and practitioners (concerning the development practice).

To further investigate the research and development practice in mobile learning the next chapter addresses the methodological considerations and the methods utilized in this thesis.
Chapter 3
Methodological Considerations

This chapter presents the methodological view of the thesis, providing an introduction to interpretative research, research methods utilized, the overall research process, and the distinguishable data sources. The data sources are briefly introduced in relation to the method or methods used and which publications they correspond to. In the publications appended there are more elaborated details on the data sources and methods.

3.1 Interpretative Research

The concepts of methodology and method can be confusing and easily misinterpreted, as discussed by Checkland (1999b). In brief, he states that the methodology is a set of principles for the method. The seven principles for interpretative field research proposed by Klein and Myers (1999) serve as an example of a methodology.

The first and overarching principle of the hermeneutics circle suggests that all human understanding is achieved by alternating between the interdependent meaning of parts and the whole that they form. This is the fundamental principle that the other six expand from. Second in line is the principle of contextualization, which ensures that the relevant context is decided and boundaries are drawn up. Third, the principle of interaction involves that the researcher “creates” data in the field and that the material is by definition socially constructed through constant interaction. The principle of abstraction and generalization is given as number four, which requires the application of principles one and two to enable providing general theoretical concepts that describe the nature of human understanding and social action. Five, six, and seven are also interconnected, and the principle of dialogical reasoning (no. 5) emphasizing the researcher’s own intellectual history as an influential part on the research and how the principle of multiple interpretations (no. 6) needs to be acknowledged using the principle of suspicion (no. 7) to ensure that the data is handled sensitively and under a scrutinizing eye.

So in brief, a methodology provides general thoughts on how to solve a problem. Further, it states common ideas, concepts, and how to understand them. Still, the ideas and concepts from the methodology also reflect how the problem is perceived by the researcher, who needs a deep insight into
3 Methodological Considerations

the problem situation. This determines the application of a particular research method (or methods). In line with this, all methods have weaknesses and strengths as this variation in applying research methods and the underlying tool set (i.e., that the same data gathering techniques can be used in different methods) depends on the research problem and on the researcher (i.e., Weltanschauung, training, and skills), as acknowledged by Hirschheim (1985). Yet again, understanding the problem situation is important when deciding the way the research should be carried out. The research question and the data that are to be extracted should be the guide. Järvinen (2004) explicitly mentions that the researcher always has a personal motivation to perform a scientific study and that this greatly influences the research and the type of outcome expected. Here, for example, the attitude and stance of qualitative and quantitative are important, as all methods inherently possess both qualities. However, this stance functions within different assumptions about the nature of the world and requires a different attitude towards tools and procedures. Quantitative research usually puts more emphasis on a positivistic paradigm and qualitative research on a more interpretive paradigm, as mentioned by Baskerville (1999).

Researchers working within the positivistic paradigm see reality as separate from themselves, and expect everybody to have the same perception of the shared phenomenon and thus common understanding. Researchers working within the interpretive paradigm see reality as a social construct and do not necessarily expect others to have the same perception or understanding of a shared phenomenon (Robson, 2002). The interpretative paradigm supports the belief that reality is constructed by subjective perception and that predictions cannot be made. However, probabilities rather than certainties can be expressed. Interpretive researchers act on the assumption that reality is being created and constantly re-created in respect to social situations (Checkland and Holwell, 1998). Researchers who agree with this paradigm are interested in the study of social and cultural phenomena. With reference to Argyris et al. (1985), the crucial elements in a research approach, which works within a special social situation, are:

- a collaborative process between a researcher and the people in the situation,
- a process of critical inquiry,
- a focus on social practice, and
- a deliberate process of reflective learning.

Under the interpretative umbrella, understanding is thus about seeing a phenomenon, which is happening in reality as something worth addressing. This can, for example, involve seeing patterns in the empirical material that, linked to a wider theoretical frame, can provide greater understanding of the phenomena. From this perspective, interpreting is about seeing things in new ways, or assigning new meanings to them. Thus, the interpretative researcher is engaged in a dialogue with both empirical and theoretical
material according to Alvesson and Sköldberg (2000), interpreting them in combination, and creating new theory from it. This type of research process is very demanding in terms of choices and ethical considerations in regard to applying theories and collecting empirical material. However, the result is often novel, surprising, and thought-evoking, and contributes to a theoretical refinements in an academic setting together with relevant perspectives for practitioners.

In interpretative research gathering empirical material and utilizing prior knowledge of the phenomena are also interrelated, meaning that researcher moves back and forth between pre-established foundations from methodological stance, theoretical considerations, empirical observations (data), and the enhancement of the before-mentioned aspects. This iterative analysis is an adequate description of the actual interpretative research process but when presenting this kind of research, Suddaby (2006) advises a more linear approach in order to communicate and give an understanding of the resulting contributions to other academics and practitioners. This advice has been the guiding-star in presenting the research process.

Figure 3.1 is provided in order to give an account of the overall research featuring the interpretative and iterative processes (depicted as a two side-by-side spirals) in combination with methods (depicted as four parallel downward branches) and the manifestations in the shape of publications (depicted by a square with the consecutive Roman number of the specific publication) that have been produced. In total, a thesis emerges as a final result (also shown as a square). In essence, the interpretative and iterative processes form an infinite loop, which (in practice) comes to a (fictitious) stop as the researcher reaches a point of sensible meaning, free of inner contradictions, which is then described, reviewed, and (hopefully) published.

In other words, Figure 3.1 is an illustration of how the overarching research process can be depicted, specifying the helix movement inherent of the methodology in interpretative research. The connection points between methods and publications are shown, and the end product, i.e., the thesis, is integrated at the bottom of the figure. The thesis, or rather the cover paper, is regarded as a ninth publication. The eight publications are appended to the thesis in their entirety, each one making its own contribution, but together they also make an overarching contribution. This contribution, the sum of the eight appended papers, is reflected in the cover paper. This is illustrated by making the methods, i.e., the four branches, overlap with the square representing the thesis. The normative branch overlaps the thesis square—more than the other methods, as the main contribution, i.e., the framework, can be considered normative.

The interpretative and iterative research processes are what best describes the research conducted in this thesis. These together provide the core principles for the research, leading up to the selection of appropriate research methods, which should coincide with the research question (cf. Chapter 1), the theoretical foundation (cf. Chapter 2), the empirical data to be gathered (cf. Chapter 4), and the researcher’s abilities.
3.2 Research Methods

There are four research methods relevant for this thesis. These are action research, field study, survey research, and normative research. An introduction and the fundamentals of each of these methods are given, starting with action research.

Some fundamental features of action research are stated by Järvinen (2005), for example, that the researcher should contribute to the practical concerns of people in a situation, which means taking action and evaluating the action at the same time, both to be carried out between the researcher and the population concerned. As the word action implies, the researcher is engaged actively, which profits both the organization and the researcher, in combining practice and theory. This is in line with the ideas of Baskerville and Myers (2004), who argue that the goal of action research is to solve a problem in a real setting and also to make a knowledge contribution. According to Darke et al. (1998), the researcher is to be an active participant and the empirical observations and material gathering are performed acknowledging the prior theoretical standpoints. A researcher needs to be able to balance this heavy involvement as well as the strengths and weaknesses that follow. The argument to be particularly mentioned is the involvement issue, which can be criticized as the researcher is coupled so closely to the situation and may lose the critical stance (Checkland and Holwell, 1998).
Action research is particularly suited for being applied in a real and natural setting and in studying social and cultural phenomenon (Myers, 1997). According to Baskerville and Myers (2004), the researcher actively participates in solving a problem while at the same time evaluating the results and making a knowledge contribution at large. For example, it allows for the introduction, transformation, evaluation, and extraction of theories. The advantage of being so engaged in the activity facilitates first-hand understanding and supports the learning process for all those involved. However, the disadvantage is that it can be very time consuming, and since the researcher takes part in the phenomenon studied, remaining at a critical stance can be hard. On the other hand, this unique position of in-house work allows the researcher to produce highly relevant results while informing theory simultaneously (Baskerville, 1999, Baskerville and Myers, 2004). Even though the outcome is attached uniquely to the research conducted, it does offer a degree of external validity, since others can interpret the theoretical contribution made. Nevertheless it can still be difficult to generalize from. In relation to mobile learning, action research provides an opportunity for a researcher to jointly collaborate with the “team.” Further, action research, as a method, has been recognized in the information systems research community and entered into journals as well as conference proceedings, according to Avison and Myers (2002).

Wadsworth (1998) points to the difference between action research and field study, and how they relate to the phenomenon studied. The emphasis of action research is participation, while field studies are more non-participatory. In a field study, the researcher sets up a number of variables, collects data, and contributes conclusions and recommendation based on the data. In action research, the researcher is actively engaged in the field, reflecting on the results, and bringing about changes. An important part of action research is to make a contribution to practice.

So, field studies are also characterized by taking place in a natural setting, but allowing the researcher a flexible stance in respect to variables, as well as the degree and manipulation of the same. However, as the control over the variables increases, pragmatism decreases. Using a range of qualitative and quantitative approaches, data is often collected through observations and interviews, supporting the study of complex situated interactions and processes as addressed by Klein and Myers (1999). The phenomena are placed in a social and cultural context. The advantage is acquiring a corpus of data, realistically extracted in a relatively short time. The disadvantages are unknown biases, extensive data collection, and having no guarantee that the data is representative.

Survey research on the other hand, provides information from a defined population and the data, which is gathered directly through, e.g., interviews, questionnaires, and publications, is assumed to be independent of the environment as stated by Fowler (2002). In essence, data from survey research is collected without the researcher intervening or having a stake in anything other than the gathering of data. Data is most often analyzed
quantitatively, but data from, for example, interview surveys can also be analyzed qualitatively. According to Gable (1994), survey research has three distinct characteristics. The first being designing and producing quantitative descriptions of some aspects of a study population. The second is collecting the data in a structured and pre-defined way. Thirdly, the data is generally collected from a fraction of the population, but this is done in such a way that generalizations for the whole population can be made. The advantages are that they facilitate large amounts of data to be gathered with relatively little effort, supporting broad generalizations of results. A high level of control regarding sample subjects also makes the reduction of bias possible, and thus increases validity. However, a disadvantage is that it suffers from providing only snapshots of the studied phenomena and relies heavily on the subjective views of the respondents.

While normative research can be described as less rigorous in terms of research method per se, it instead addresses interesting phenomena from a pragmatic standpoint. This is done in order to stimulate and indicate directions for future research, and for example covers writings of application descriptions, idea, concept, and suggestion development (Tolvanen et al., 1996). The narratives often seem intuitively correct but are not exclusively based on theory or fieldwork, as well as being presented according to the style of a practitioner, i.e., giving an intimate and subjective view, focusing on what worked in a particular situation. Often the publications give an insight into first-hand experience and form the basis for other forms of research, but opinions might influence the research. The advantage is that this kind of writing is more straightforward and often perceived as easier to produce compared to presenting complex theoretical contributions. The drawbacks consist of limited theoretical foundation, weak methodological reflection, and low generalizability. However, the ones that reach the stage of publication often provide well-prepared arguments with considerable backing from other sources. Normative research is used to give descriptions of practice, conceptual modeling, and informing and teaching concepts.

### 3.3 The Research Process Explained

The iterative cycle of planning, acting, observing, and reflecting supports the analysis of an application and problem area and has been utilized for the overall research. It is a cyclic process involving four linked phases, illustrated in Figure 3.2 (Kemmis and Wilkinson, 1998). The theoretical contribution emerged through iterations of action research cycles (Baskerville, 1999).

To further explain the overall research process, field studies, and survey research have been planned, ongoing action and observations made, in turn the gathering of the empirical data have been accompanied by constant reflecting, specifically in terms of also making theoretical connections. The main aim was always to contribute to the practical concerns of people in
a problem-riddled situation and to develop a theoretical contribution that could possibly help to increase the competence and self-help ability of researchers and practitioners in the field of mobile learning. The theoretical contribution (i.e., a framework) emerged through the process of identifying findings and specifying these.

In order to analyze the application area, the iterative cycle of the action research approach was utilized, reflecting on the research being part of the iterative cycle. The experiences gained during this research created the opportunity to contribute to the theoretical enhancement and to define a framework that attempts to illustrate scalability. The aim is for the framework to be useful to get sustainability in the information systems development process and as a thinking aid for researchers and practitioners working in the mobile learning community.

According to Holter and Schwartz-Barcott (1993), an action researcher handles and bridges theory, research, and practice. One characteristic of action research, specified by Hult and Lennung (1980), is that the approach is applicable primarily to understanding change processes in social systems. The author of this thesis was new to the fieldwork connected to mobile learning, but entered the field with a theoretical, as well as a research background. Fieldwork and, consequently, field studies have been the method to really understand the problem situation and get a thorough understanding of the situation at hand. Through survey research more empirical data has been gathered to support the overall learning process and get a substantial amount of material to support the other methods in a more quantitative way.

The mixture of research methods – triangulation – is advocated by Mingers (2003) on the grounds that both the target of the research and the research process are complex and multidimensional, requiring a range of different data collection approaches in order to produce richer and more reliable results extracted from more data sources. Triangulation is also discussed by Yin (2003), who emphasizes that the use of multiple sources of evidence impose a great burden on the researcher, who needs to master a variety of
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data gathering techniques and the extensive collection of data they produce. Further, Yin (2003) presents four types of triangulation, hence

- of data sources i.e., data triangulation,
- among different researchers i.e., investigators triangulation,
- of perspectives to the same data sources i.e., theory triangulation, and
- of methods i.e., methods triangulation.

Lee and Baskerville (2003) present a noteworthy distinction between empirical and theoretical statements. Empirical statements can refer to data, measurements, observations, or descriptions about a real-world phenomenon, while theoretical statements postulate the existence of entities and relationships that cannot be directly observed, and hence only be theorized upon. Reflecting on the learning process and providing new contributing results fall under a normative method and so does this thesis, which is a vehicle for reporting on the overall research endeavor.

One major consequence of the choice of action research as a method is that the research outcome is context-bound as opposed to context-free (Horsburgh, 2003). It is difficult to determine the cause of a particular effect, which could be due to the environment (including its subjects), the researcher, or the methodology. Even though the results of action research are more qualitative in nature and attached uniquely to the research, they do offer a degree of external validity, according to Avison et al. (2008), since the theory developed can be interpreted and refined by others in other real-world situations.

Furthermore, Avison et al. (1999) say that an action researcher can address complex real-life problems, and the resulting contributions are of immediate concern to practitioners, although the findings as well as their presentation need to be in accordance with this audience and often of a descriptive character, as recognized by Small (1995).

3.4 The Data Sources

The empirical data used to support the research is gathered from four distinguishable data sources. A data source can be put in relation to another data source and form a *unit of analysis*. It is once the researcher has decided on the level of analysis that a unit of analysis can be defined. To further explain, the unit of analysis, according to Robson (2002), is the entity that is being described and analyzed during a specific research study. The material has then been used to study a number of different aspects of the information system development practices in mobile learning. Next, a short description of the data sources, methods, and data gathering techniques are mentioned, and which publication or publications it corresponds to (i.e., where further and more details are provided).

The first data source is a mobile learning initiative at Canterbury University, Christchurch, New Zealand. The author of this thesis was an active
participant in the initiative, and the data was gathered during this participation by the use of a number of methods, i.e., field study, action research, and normative research. Different data gathering techniques have been applied such as interviews, questionnaires, observations, and literature review. The research is addressed in Publications I, III, IV, V. Additionally, further reading can be found in Wingkvist (2008).

The second data source constitutes of all the mobile learning initiatives within Kaleidoscope. Kaleidoscope is a Special Interest Group and a European Research Network of Excellence in the field of Technology Enhanced Learning. The research was basically an investigation and the methods utilized were normative research, survey research, and field study. The empirical data was gathered through interviews (with 3 project managers), questionnaires (targeted all 30 project managers, although with 50% answer-rate), and a literature review (28 publications). The research is presented in Publication II.

The third data source is two initiatives from the CeLeKT (Center for Knowledge and Learning Technologies) research group, Växjö University, Växjö, Sweden. The author of this thesis participated in part in these two initiatives, and was also able to rely on data gathered by other researchers that participated and on informal interviews with these researchers. The method employed is field study and the empirical data was gathered through interviews, observations, questionnaires, and a literature review. This is addressed in publications VI and VII.

The fourth data source consists of 76 research publications from two proceedings of the World Conference of Mobile Learning (in short called mLearn). mLearn is the leading conference in the field of mobile learning. The method used is survey research, and the data was gathered through a literature review. This research is addressed in Publication VIII.

In the next chapter the eight publications are introduced briefly with title and the name of the international conferences they were presented at, followed by summaries.
Chapter 4
Overview of Research Efforts

This section presents an overview and summaries of the appended publications (Bell et al., 2009, Wingkvist and Ericsson, 2009a; b; c; d; e; f; g).

In brief, publications I, VI, and VII, address the development practice of mobile learning initiatives. Publication II evaluates how a socio-technical risk assessment model can be applied on mobile learning initiatives. In publications III, IV, and V, central concepts are discussed and a development framework is presented, along with the motivations behind it. Publication VIII analyzes the research process in terms of methods and purposes for a number of publications in order to find out the prevalent trends in the forefront of mobile learning research.

The eight appended publications together form a complete picture of the research conducted. In other words, this thesis consists of eight peer-reviewed scientific publications that have been presented at different international conferences. Five of the papers explore the field of mobile learning and its practice, while the other three publications present the central ideas that serve as the basis for the proposed framework, how it has been developed and the motivations behind its creation.

The following is a list of the appended publications. The rest of the section contains a summary of each of them with a focus on purpose, method, and results.


4 Overview of Research Efforts


4.1 Publication I

This publication presents a field study and survey of how podcasts, digital audio files, can be used to supplement university level courses. Podcasting can be used as a highly mobile learning aid, one that some universities were fast to adopt.

The audio-only format offers the possibility to listen to podcasts while doing other activities, and thus offering students a way to extend the number of hours they study without imposing on the time they need for other activities, such as commuting, household chores, or physical exercise. However, by combining learning with such activities, it is necessary to be aware of distractions, the inability to take notes or look up references, etc.

In order to see if podcasts could be utilized “on the go,” an experiment was performed where weekly podcasts were offered on two first-year courses in computer science. The format of the podcasts varied in order to measure what the students preferred.

The experiment shows that podcasts can be a low-effort and effective supplement to regular lectures. It is however important to keep them short and to the point. In a similar sense, the critical point is to deal with any technical problems quickly and aggressively, so that if they occur, not to make students lose faith in the idea and its realization.
The publication presents a description of the experiment as well as an analysis of the questionnaires. It also summarizes the most important lessons learned from the experiment in a list of do’s and don’t’s.

The main contribution is an understanding of the difficulties of trialing a mobile learning aid for a large-scale audience and designing a learning scenario, tying the location, the learning experience, and the task together.

4.2 Publication II

Risks, in information systems development refer to unsatisfactory outcomes, such as poor quality or budget overruns. A great deal of effort has been put into means, such as theoretical (conceptual) models to assess and control risks. This publication studies the problems suffered by many mobile learning initiatives, often due to unforeseen events, and relates these events to risks in an attempt to benefit from risk management.

In order to study what risks mobile learning initiatives experience, several projects are studied from different angles. First, interviews were conducted with project managers. The outcome from the interviews was used to create a questionnaire that was sent to all the project managers within a major European network for mobile learning research. They were asked to answer questions related to risks experienced within their most current but finished project as well as to name all publications from that project. The questionnaire had a response rate of 50% (i.e., 15 project managers), and 28 publications were listed.

To analyze the questionnaire and publications in order to find and classify risks a risk assessment model was used. Initiatives in mobile learning can be considered socio-technical, since they aim to develop learning activities supported by technology and, in turn, a model for socio-technical systems should be used for the analysis. This publication used a pre-existing risk model (originally based on Leavitt’s diamond). The risk assessment model contains four components, Technology, Task, Actors, and Structure, as well as the six relations between these for classifying risks. One risk could, for example, be placed in the interaction between Actors and Technology.

The analysis of the questionnaire and publications identifies a number of risks that can be classified according to the model. This suggests that a risk assessment before the project should find at least some of the risks experienced, and dealing with the risks beforehand might result in improved sustainability. However, the research also finds that the model is quite demanding and difficult to use. Many of the risks that were found in the publications and the questionnaire related to interactions between one or more components, but it was hard to pinpoint one such interaction – since most related to several interactions – and a classification resulted in approximations. In order for the model to be useful to mobile learning researchers it should be adapted to better suit the research field.

The main contribution is pointing out the mismatch when using a risk
4 Overview of Research Efforts

4.3 Publication III

In this publication the evolution of a mobile learning initiative is considered to consist of four stages, Idea, Trial, Project, and Release. Each of these four stages represents a prototype that should be validated within the stage. In order to better reason about the activities during the evolution the concepts of Scalability and Sustainability are introduced. Scalability refers to the transition from one stage to the next, i.e., considering and making all the changes that are required. Sustainability refers to the validation within each stage, a stage that works according to some predetermined specification being considered sustainable in that stage. An initiative that reaches the Release stage and is sustainable there is considered a sustainable initiative.

Scalability concerns evolving from one stage to the next. This includes planning what to change, considering how these changes will affect the initiative, and on this basis either carrying out the changes or returning to planning it again. It is important to consider the effect of the changes and how they propagate throughout the initiative. The changes will form a ripple effect and even those that seem to have little effect on the end product, such as moving from one technical platform to another, might cause a number of unanticipated changes. Scalability concerns both realizing how a change will ripple through the initiative as well as how to limit its effect.

Sustainability is important in relation to scalability, as sustainability defines the beginning and end of scalability. An initiative can only scale once the current stage is sustainable, since it is impossible to plan changes to an unstable stage. The scaling effects are not over until sustainability is reached. Scalability is also important to sustainability, since the former becomes the means of achieving the latter.

The main contribution is the discussion of scalability and sustainability and their relation as a means of achieving sound mobile learning initiatives.

4.4 Publication IV

This publication presents a study of the development practices of an initiative that used podcasts to supplement lectures in higher education. Data was gathered using the iterative cycles of the action research approach. The empirical material was analyzed which resulted in a framework that shows how sustainability and scalability are linked. The framework also shows how an initiative is developed from Idea, to Trial, to Project, to Release, and how each of these stages can be described using the four areas of concern, namely, Technology, Learning, Social, and Organization.

Drawing on the experience from a specific mobile learning initiative to define a framework that is then used to conceptualize the development pro-
cess is a way to bring together practice, theory, and research, and thus provide reliable evidence for the framework itself. The framework captures the development and the relevant context in a unified theoretical attempt and is suitable for practitioners, i.e., people that are actively engaged in and dealing with initiatives in the field of mobile learning.

The main contribution of this publication is to present both the motivation behind and the framework.

### 4.5 Publication V

In this publication a meta-model (i.e., a framework) is presented to describe the development practices of mobile learning initiatives. These initiatives are often small-scale trials that are not integrated into the intended setting but instead carried out outside of the setting. This results in sustainability issues, i.e., problems to integrate the results of the initiative as real learning aids. In order to address the sustainability issues and, in turn, help to understand how to scale up, a framework is introduced. The framework was used to describe and analyze a specific mobile learning initiative, an initiative where supplementary material was delivered to undergraduate students through the use of podcasts.

The framework presented consists of two dimensions, namely evolution and areas of concern. The evolution describes how an initiative evolves through four distinct stages: Idea, Trial, Project and Release, and the areas of concern is a means to reduce complexity by grouping issues into four problem situations views: Technology, Learning, Social, and Organization. Each of these stages and areas has a special meaning. For example, Trial represents a small-scale test and Technology addresses all the issues and problems relating to, for example, hardware and software. The concept of Focus is used to guide the development process and show what is important during each stage, and the Equilibrium concept is used to deal with the iterative development that happens within each stage. The notion of Scalability is the transition between two stages, and the notion of Sustainability is the measure of how well an initiative solves the problem it was intended to solve and how well it fits the setting.

The main contribution of this publication is to present the framework in a neat “package”, fast to read and in an easily accessible format targeted especially to the mobile learning community while also opening up towards researchers in the overall Technology-Enhanced Learning (TEL) field.

### 4.6 Publication VI

This publication presents a study of three initiatives in mobile learning, which were compared with regard to how stakeholders were dealt with. It is acknowledged that the work to identify and access the relevant stakeholders is inherently difficult and with this follows a magnitude of factors
to consider. The goal of these initiatives is to reach a viable design for
the initiatives as such and for the outcome to match the intended audi-
ence. Reaching a viable design can only be done by a sound development
practices. It is shown in this field study that these mobile learning initia-
tives often follow an evolutionary life-cycle where the information system is
constructed, evaluated, and refined in increments.

During this, the stakeholders and their needs might change, so even if
there was an initial understanding, it might not be correct after one or
more increments. Further, the initiatives dealt with stakeholders differently
in getting their input but essentially identified and interacted with stake-
holder groups in an on-demand fashion, taking them in turn, and locking
down requirements in steps. In other words, new groups of stakeholders are
considered when needed, and this leads to development practices that are
a mix between the sequential and the evolutionary life-cycles, which results
in inflexible information systems solutions. In order to improve on this,
stakeholders need to be regarded in a more inclusive fashion, whereby they
are considered as part of the entire development process.

The main contribution of this publication is to explicitly compare and
understand how stakeholder analysis were dealt with as part of the system
development practices.

4.7 Publication VII

This publication presents lessons learned from three mobile learning ini-
tiatives. Past experiences provide an important source of new knowledge.
By reflecting on what happened previously others can avoid repeating the
same mistakes. Studies of published results in the field of mobile learning
show that they often revolve around isolated technologies and report on
specific small-scale trials rather than making broad reflections on practice
and outcome.

In connecting longitudinal and accumulating experience involving three
initiatives in this field study, the main point of the investigation is on the
development practices. Even though, or because, the initiatives had dif-
ferent aims and used different technologies and approaches to learning, the
crystallized and overarching lessons learned can serve as considerations or
guidelines for other researchers when starting new initiatives in the same
field.

The study identifies a number of concerns where one or more of the three
initiatives experienced difficulties. The three initiatives took different ap-
proaches to deal with the these problems, depending on the approach and
the aim of the initiative. For instance, two of the initiatives relied on
custom-made software, developed exclusively for the initiative, while the
third initiative exclusively used commercially available technology. The lat-
ter approach is less flexible, but might prove cheaper and experience less
difficulties. The extracted considerations are presented as lessons learned.
In summary, the lessons learned and guidelines revolve around the basis of technology, spanning over connectivity aspects and data management, continuing with scenario building, the choice and design of evaluation method, and co-operation with stakeholders.

The main contribution of this publication is the presentation of lessons learned, extracted from three longitudinally conducted studies, compared and analyzed in respect from an information systems development perspective.

4.8 Publication VIII

In this publication a literature review was conducted to better understand research conducted in the field of mobile learning. Papers were classified according to two dimensions, research method and research purpose. The research purposes considered were Describing, Developing, Understanding, and Evaluating. The research methods considered were Case study, Field study, Action research, Experiment study, Survey research, Basic research, Applied research, and Normative research. In order to capture current research the review targeted the conference proceedings of mLearn 2007 and 2008, which in total consist of 76 full papers. Each paper was analyzed in depth by more than one person and classified according to purposes and methods. Many of the papers can be classified as having a number of purposes or methods, but the most coherent and dominant from each category were selected to classify the paper according to the two dimensions, respectively.

The survey found that, generally, the research conducted is either close to one situation in particular, gathering empirical data and describing it, or presents ways to utilize the essence of mobile learning in an abstract sense on a normative level. These two represent opposite ends of the spectrum, given method and purpose choice, and out of the 76 papers considered in this survey, 51 papers fall into either of these (67%). The prevalence of gathering empirical data and the research that is conducted to describe a phenomenon show a strong connection to real-world cases.

A great deal of the research conducted is done to describe how the real world works and is often presented as the result of a small-scale study with a population using mobile technology for learning reasons. This data is presented, not interpreted, and offered as a description of the learning process. At the other end of the spectrum there is normative research, which is also conducted with the purpose to describe and develop. Many of the papers that fall into this category present either a description of a current situation or a future situation describing what may happen or how something should be developed.

The main contribution of this publication is to present and collate current research practice in the field of mobile learning.
4.9 Summary

The aim of the research presented in this thesis is to form a better understanding of the development practice in mobile learning and to contribute to the same. Each one of the eight appended publications contributes to this goal on their own. However, two main tracks can be distinguishable in the research. First, a study of the field of mobile learning was needed to gain an understanding of the area and the problems experienced. Secondly, to address the problems raised, a possible solution was provided.

For instance, the five publication that studied current research and development practice together form a larger picture of the field. By studying the development practice from different perspectives, using different data sources and methods, a more complete picture of this field can be formed.

In contrast, the three publications relating to the framework, the main contribution of this thesis, paints a larger picture in a similar way. Publication III introduces the importance of scalability and sustainability, but does not consider how they came to be. Publication IV, on the other hand, gives a detailed account of the construction of the framework and the theory the framework is based upon, while Publication V introduces the framework on an accessible level.

The eight publications also form together a map of how the research proceeded, from the practical fieldwork, through reflection, to the formulation of a framework (i.e., a theoretical contribution).


Chapter 5

Discussion

This chapter discusses how the research presented in the appended publications (summarized in Chapter 4) addresses the research questions posed in Chapter 1. Some of the publications relate to more than one question. Table 5.1 shows how the questions and publications are related. Given the first research question this chapter starts with addressing how current research in mobile learning can be described, especially in regard to the development practice. In respect to the second research question the difference between information systems development and mobile learning is discussed. The third research question regards how knowledge from the field of information systems research and practice can be related to and applied within mobile learning. In order to address this question concepts found during the analysis of the practice within the mobile learning initiatives and how these can be related to information systems development are discussed. In answer to research question four, a number of findings are presented from a more theoretical perspective to a more practical level. And in the last section a framework is presented to correspond to the researchers and practitioners in the field of mobile learning.

<table>
<thead>
<tr>
<th>#</th>
<th>Question</th>
<th>Discussed in Publication</th>
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<tbody>
<tr>
<td>1</td>
<td>What are the current research approaches and practices in the field of mobile learning?</td>
<td>I, II, VI, VII, and VIII</td>
</tr>
<tr>
<td>2</td>
<td>How are practices in information systems development and mobile learning related?</td>
<td>II, III, and IV</td>
</tr>
<tr>
<td>3</td>
<td>How can knowledge (research and practice) from information systems development support mobile learning?</td>
<td>II, III, IV, V, VI, and VII</td>
</tr>
<tr>
<td>4</td>
<td>How can the results of this research be brought back to the researchers and practitioners in the mobile learning community?</td>
<td>I, III, IV, V, and VII</td>
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Table 5.1: Research Questions in Relation to Publications.
5.1 Current Research in Mobile Learning in Terms of Development Practice

Mobile learning is still a young field and the innovation is driven by research initiatives. This means that a great deal of the development happens as part of these research initiatives and in turn that the IT artifacts produced might affect the research outcome. In order to better understand if this is the case, a study of research publications was conducted to better understand the method and purpose of mobile learning research. The survey in Publication VIII shows that a large number of mobile learning initiatives involve studies of technology, for example using field studies, with the aim to describe it. A typical research publication might describe how students use artifacts developed by the research team to accomplish some learning goal, but without evaluating the learning. This suggests that poor development practice might indeed affect the outcome of the entire research initiative.

In order to better understand how the development within these research initiatives happens, several of them were studied and the empirical material gathered was studied from different perspectives.

Publication II presents a study of 15 projects from the perspective of which problems they experienced during and after the development. Publication I takes a different approach and studies the conception phase of a mobile learning initiative. This study focuses on the initial investigations of the research team and their effort to better understand the problem area. In Publication VI and Publication VII three different initiatives are studied in order to investigate how they developed from conception to implementation. Publication VI takes a close look at stakeholder interaction during the development, while Publication VII takes a wider look at how a number of issues are dealt with during the development, including stakeholders.

The empirical material and the analysis carried out reveal that there is seldom a well-defined development process. Most of the development is exploratory, where prototypes are produced, evaluated, and improved. There is seldom any clear understanding of the actual stakeholders, and as Publication VI shows, stakeholders are handled on an ad hoc basis and involved when needed in the development process. The post-mortem risk analysis performed in Publication II shows that such an analysis can prove helpful, but the analysis of the development practices in the initiatives reveals that only a partial and ad hoc risk analysis was performed. An example of such an ad hoc risk analysis is the initial questionnaires used during the conception of the podcast initiative, as presented in Publication I.

The analysis of the research and development in mobile learning shows that the outcomes of research initiatives are potentially dependent on the IT artifacts produced, and that the development practices for producing these IT artifacts is generally done ad hoc. This can result in non-conclusive, or even questionable, research outcomes. The mobile learning initiative in Publication I shows a typical example of this, where the poor quality of
a service (a server crash) used resulted in the loss of research data (made downloads impossible and consequently no data-logs). The repercussion could also inflict on the attitude towards further use of the service even after it was restored and back online. Hence, by improving, or at least defining the development practices maybe such issues can be avoided.

5.2 Relating Mobile Learning and Information Systems Development Practice

A great deal of effort has been put into understanding IT artifacts are developed and introduced into organizations. There is a wide range of both research results and practical considerations involved. In order to investigate how these relate to mobile learning, there is a need to understand how mobile learning and information systems development are related. This requires a better understanding of mobile learning in general, in particular how and why research and development are conducted within mobile learning, and how the systems produced are supposed to be used.

Chapter 2 discusses how the development of both mobile learning and information systems started as a technology-oriented activity and was later considered to have both technology and social dimensions. Mobile learning can be considered a socio-technical system with mobile phones and software as the technology dimension and learners and schools as the social dimension, for example.

According to Bostrom and Heinen (1977), a socio-technical system consists of the two dimensions, social and technical, which are divided into People and Structure, and Technology and Tasks, respectively. Figure 5.1 depicts this view of a socio-technical system. Addressing mobile learning using this view, the learning goal would belong to the Tasks, the pedagogy would be considered Technology, and many of the stakeholders, such as learners and their parents, would be considered People. This view of a socio-technical system does not correspond that well to mobile learning as discussed in Chapter 2.

One major goal of mobile learning is to allow the learners to be mobile
Discussion

Figure 5.2: An Extended Socio-Technical System for Mobile Learning.

in time and space, and make the learning more personal (Kukulska-Hulme and Traxler, 2005). Learning is individual and different individuals learn in different ways. Merrill et al. (1996) state “groups don’t learn, individuals learn. Learners may be part of a group while learning, learners may learn from one another, and the social context of a learning environment may provide support for its members; nevertheless the change in cognitive structure and the acquisition of knowledge and skill is an individual event” (p. 2). For example, some people may pick up something quickly, while others need to repeat the exercise several times trying different strategies. Some may understand, for example, mathematical concepts from reading about it in a book, others may need to do several exercises. Mobile learning should support all the learners and offer the opportunity to learn in their own way, as far as possible.

The individual and personal nature of learning is visible in a study of the development and outcomes of mobile learning initiatives. Publication II contains examples of this, for example “student ownership and 24/7 access to a handheld device are central to the approach”, and further along this line “where students had constant use of the mobile devices, there was evidence of a growing sense of autonomy, as students created their own uses to meet personal purposes”.

The socio-technical system view depicted in Figure 5.1 does not contradict the view that learning is personal and individual, but it does not promote it either. The division into pedagogical theory as technology, the learning goal as task, and the learner as one of the stakeholders gives a fragmented view of the learning. In order to deal with this, an extended view of mobile learning is suggested that places learning into a personal system and puts the same emphasis on it as the social and technical. Figure 5.2 depicts this extended view.

The new extended view introduces a personal system that contains the Tasks. In this view, Tasks is synonymous with the process of learning. The Technology contains all the technology, such as mobile phones and software that support the learning. The classification of People has been changed to not include the learner, but instead refer to other people he or she interacts with, such as classmates and teachers.
5.3 Mobile Learning Development Supported by Information Systems Development

The previous section introduced an extended socio-technical system for mobile learning. However, the main change is that the learning, i.e., the task, has moved from a technical perspective to a personal one, focusing on the individual nature of learning. This means that People, Structure, and Technology are unaffected, and hence, models and methods developed for socio-technical systems might still be applicable, at least to concerns that fall within these.

5.3.1 Methods and Models from Information Systems Development

In order to test whether some socio-technical models were still applicable, two studies were conducted. In one of these, three initiatives were studied in regard to how they managed stakeholders in respect to the participatory traditions of socio-technical systems design. The stakeholders analysis, i.e., Publication VI, show that while each initiative had a slightly different approach to stakeholders, the overall approach can be described as “when needed, and in turn”. Stakeholders were asked in sequence, and decisions were made before all stakeholders were consulted. This resulted in mismatches later on. By inviting stakeholders to participate in the design process and thus adopting a stance towards stakeholders similar to the one advocated by socio-technical systems design, the mismatches might have been avoided, since all stakeholders would have been consulted before requirements and consequently decisions were locked down.

The second study focused on a socio-technical model for risk analysis, so Publication II uses empirical material gathered from 15 mobile learning initiatives as a basis for such an analysis. The model by Lyytinen et al. (1998) considers risks in Technology, Task, Social, and Structure, and in the relations between these. With the application of the model a number of risks were discovered, and these found support in the results reported by the initiatives. The study found that while the model could be used, there were a number of issues involved in mapping the initiatives to it. This is supported by the discussion in the previous section, as it was problematic and unintuitive to deal with pedagogical approaches as Technology, for example. The model also felt overly complicated, and it was difficult to map risks to one out of the six possible relations. This, however, is a concern related to the model, and not due to the socio-technical view itself.

The results suggest that some practice from socio-technical system is applicable to mobile learning. The continued investigation studies the practice that is found in the field of mobile learning and relates this to concepts and knowledge found in the field of information systems development.
5.3.2 Finding Concepts in Mobile Learning

The previous section discussed how methods from information systems development could be used for the development of mobile learning. This section focuses on concepts found in information systems development methodologies.

An important part of an information systems development methodology is the life-cycle model. In their ideal form, life-cycle models can be regarded as sequential or iterative. There are many variations, but in essence the idea is to either progress through a specified number of stages or to repeat a specified number of stages until the end goal is reached.

When observing the development of mobile learning initiatives, it was found to be highly iterative, but with well defined progressions in terms of various steps. Based on observations, four major stages can be identified namely Idea, Trial, Project, and Release. Any mobile learning initiative should progress through these. Each stage represents a specific activity and specific goals. For example, the Trial stage revolves around testing the prototypes in a controlled environment with limited groups (this stage was called Experiment in Publication III but used synonymously). A stage can contain several iterative development cycles and a large number of actual trials. When a stage is considered finished, i.e., the results are satisfactory, the stage is over. It is generally difficult to go back and repeat a previous stage, so progress from one stage to another should only happen once it is “completed”.

A sequential life-cycle makes late changes very expensive. When summarizing lessons learned from Multiview, Avison et al. (1998), state that the sequential life-cycle is inappropriate for describing the development practice. However, Avison et al. (1998), also found that an iterative life-cycle can be difficult to use since it lacks a well-defined progression. In order to support an iterative life-cycle as well, each stage can be thought of as containing a number of iterations. The life-cycle is iterative inside each stage, but sequential over the four stages specified.

The extended socio-technical system for mobile learning presented in Section 5.2 consists of three systems, the social, the personal and the technical. These three systems exist in each of the four stages of the mobile learning life-cycle. To incorporate them and make the visible, each stage is divided into four Areas of concern. The additional area is created by dividing the social system into Social (People) and Organization (Structure). The other two areas are Technology (Technology) and Learning (Tasks). Technology is the hardware and software used, Learning includes the pedagogy and teaching goals, while Social includes how students and teachers use and interact using the technology. Organization represents the organizational concerns, for example laws and regulations, and school policy. The name areas of concern is inspired by Checkland (1999b) and how he reasons about a problem situation.

The areas of concern can be considered as views. Each area of concern
5.3 Mobile Learning Development Supported by Information Systems Development

deals with a specific aspect of mobile learning and can be linked to a specific
group of stakeholders. Since the four areas of concern represents different
views on the same IT artifact, they are interlinked. A change to one of the
areas will affect the others. For example, consider that there is a request to
move the podcast initiative (presented in Publication I) from audio only to
include video. At a technical level, this might be easy since many devices
include video capabilities these days, but it would affect the learning since
video cannot be used as easily while “on the move”. Similarly, it would
require video recoding and editing software and hardware, as well as server
support to distribute the video. By discussing how any decision will affect
the four areas of concern, there is a built-in analysis of how a decision affects
stakeholders and what possible risks it might create.

The areas of concern support the iterative development practices within a
stage. Changes will propagate between the areas, and result in new changes
that will propagate in turn. However, as discussed previously, there is no
defined progression, and the propagating changes may make it more com-
plex. In order to deal with this, mediation between the areas of concern is
needed. The concept of focus is introduced in order to provide mediation
and reduce complexity. This is inspired by Avison and Wood-Harper (2003)
reasoning about mediation using the metaphor of a camera (for more details
see Publication IV). Using focus it is possible to see all four areas at the
same time, but only by sacrificing the level of resolution. So, it is possible to
focus on and examine one particular area in great detail, but at the expense
of losing some of the greater context, which is depicted by Figure 5.3, where
the Social area of concern is in focus.

The use of focus in relation to the areas of concern provides a sequential
progression. Each area of concern is focused on in turn, and the main
development objectives revolve around that area. Changes to one area will
still affect the others and need to be managed, however, by only focusing
on one area — one potential source of change — a sequential progression is
maintained and complexity is reduced.

In order to deal with the interlinked areas of concern and the propagating
effects that a suggested change will have, the notion of equilibrium is intro-
duced. This is similar to Leavitt’s model for organizational change (Leavitt,
1965) where the term equilibrium is used to signify that the opposing forces
of a change are in a steady state, i.e., the effects of the change have been
compensated for. The term is used in a similar manner here, where it sig-
nifies that a change has propagated to all related areas of concern and that
each area has been adjusted to deal with the change. To continue the ex-
ample with video podcasts, any stage where the effects of introducing video
to one or more areas are ignored will not be in equilibrium. A system that
is not in equilibrium will contain risks not assessed that might result in a
failure to obtain any or all of the benefits of the IT artifact at a later stage.
Since there might be risks not considered in a stage that is not in equilib-
rium, it is not possible to progress to the next stage before equilibrium is
reached.
The steps and exploratory development used by mobile learning initiatives contain a growth process. They transition through several stages, starting from a few users with mock-up prototypes to larger groups with real hardware and software. The users early on might be members of the development team while the users later on will be closer to the target audience. In essence, each change to either of these variables changes the scope. Consider the research initiative in Publication I where podcasts were used as learning aids and the production of podcasts needed to be supported. When the initiative grew to include teachers outside of the team that started the initiative, there was a need to support them by providing hardware and software to record audio as well as assistance in using these. The growth process, or rather the ability to scale up is an important part of the exploratory development used in mobile learning initiatives.

In the field of Computer Science the term scalability is considered a quality of, for example, a network or a system. If an information system is not scalable, it cannot handle an increase of factors. The understanding of scalability is often vague or subjective, but a number of research efforts to define this notion have been carried out. Laitinen et al. (2000), in addition to Weinstock and Goodenough (2006), give a good overview of the underlying concepts and problems of scalability in information systems development. Bondi (2000), in relation to an information system, judges how scalable it is when the information system needs to accommodate to changes, for example a higher demand in terms of more users or hardware.

Scalability can be considered as the initiative’s ability to grow. This growth, in respect to all the four areas of concern should be able to handle the different types and groups of users and organizations with everything that this entails. There will always be a point at which scalability stops making sense, i.e., the largest rational organization it can scale to or a “market” that can be “controlled”. Using this description, scalability can be defined as the ability to reach a state that matches the pre-set requirements at a development stage (more addressed in Publication III). The more stages at which it reaches these, the more scalable the initiative is. In this respect, saying that a mobile learning initiative is scaled to the Project stage simply means that the initiative reached a state in accordance with the specified variables at the Idea, Trial, and Project stages. The components were in unison with each other at each stage.

The term sustainability is defined by Eckersley (1998) as the ability to continue an activity or maintain a certain condition indefinitely. Black (2004), in connotation to communities and societies, says that sustainability
The development of a mobile learning initiative goes through a number of Stages. Mobile learning initiatives go through a development process that can be summarized using the following four stages: Idea, Trial, Project, and Release.

Each stage deals with a number of concerns or requirements that deal with different aspects of the mobile learning initiative. There exist an interplay of technical, pedagogical, people-related, and bureaucratically considerations and these are called, in short, the following areas of concern: Technology, Learning, Social, and Organization.

Focus is a way of reducing complexity. Each stage deals with the areas of concern, but it was found that certain areas are more prominent during certain stages. By applying focus on particular areas, these provide the primary concerns to investigate.

The concept of Equilibrium is the measure of when the inner development process has reached a “final” state. When all the concerns within a stage, both those within areas in focus and those indirectly affected by the focused areas are in balance, equilibrium has been achieved.

Scalability indicates how well the initiative is able to grow. When an initiative reaches equilibrium at one stage and is able to refine or add to the considerations within the areas of concern that should be dealt with in the next stage, it can then transition from one stage to the next. Scalability is the measure of how many such transitions the initiative can accomplish.

Sustainability is the measure of how well the result fits the intended setting. An initiative that has reached a stage with realistic and “final” concerns and reached equilibrium at this stage is considered sustainable.

Table 5.2: The Key Concepts Summarized.
is being increasingly seen as involving three interrelated dimensions: the economic, the social, and the ecological. When applied to systems in a general sense it relies on Beer (1984), who states that a viable system in order to survive needs to be organized in a way to meet the demands of an ever-changing environment. The Darwinian saying *survival of the fittest*, from his theory of natural selection comes to mind, and a living system needs to be able to maintain a separate existence over time.

Traxler and Kukulska-Hulme (2005) discusses sustainability in relation to mobile learning. The end product (i.e., the information system) of a mobile learning initiative needs to be stand-alone in relation to its creators and sustain an existence by itself in the intended setting. A sustainable mobile learning initiative would be one that reaches the last stage, i.e., the Release stage, and is incorporated into the targeted environment. The goal is a mobile learning initiative that survives on its own merits and adapts to changes in the environment. By combining the definitions of scalability and sustainability, sustainability is the same as “maximum” scalability. The key concepts are summarized in Table 5.2 (Additionally, see Publication IV).

### 5.4 Contributing Back to Researchers and Practitioners in Mobile Learning

The discussion in relation to the first and second questions deals with what mobile learning is and how the research is conducted. The third research question involved both direct practical lessons learned, such as keeping the podcasts short, as well as how the practice can be strengthened by knowledge from the field of information systems development to form new concepts, such as Focus. Considering the nature of these results, there are three ways to present the results of this research: as new theoretical contributions, as a framework for mobile learning development, or as a set of guidelines and/or lessons learned.

From the studies of previous initiatives and the discussions in the appended publications there is a diverse set of researchers and stakeholders to mobile learning that in turn can be considered practitioners. There are developers, students, teachers, school administrators, and so on. The framework should be suitable, understandable, and useful to each of these groups.

#### 5.4.1 The Three Categories of Contributions

New theoretical contributions, such as the extended socio-technical system for mobile learning, are more aimed at the research community of mobile learning. The main consumers of such a result would be the researchers working towards conceptual modeling, such as the ones discussed in Chapter 2, seeking theoretical foundations and communication platforms for their work. While the conceptual models would expand the theoretical foundations of the field, they will contribute to the practitioners of the field via
the researchers. Hence, the results might find their way to the practitioners and thus improve communication and collaboration in the development practices.

At the other end of the spectrum there are the guidelines and the lessons learned, such as the ones given in Publication I. These are often presented in the form of do’s and don’ts, speaking directly to other practitioners such as teachers. They represent knowledge that is easy to access and understand, but might prove hard to put into practice. For example, consider “involve the stakeholders” and “keep the podcasts short”. While they are offered on two different levels, they both prove hard to use effectively. Other issues concern how to relate various lessons learned to each other, or to deal with the large number of guidelines and lessons learned that are bound to be produced. They are, however, the quickest form to bring results and reflections back to the community. Publication VII is an example of this.

Checkland (1999b) made a point of saying that the intention behind the activity of research is to establish well-founded knowledge about the world and about the phenomena happening in the world. He continues stating that the incorporation of scientific conduct in our (Western) culture has muddled the distinction between theory and practice (craft), and the combination of the two. So, to de-muddle it to three categories, theory is considered a scientific contribution, guidelines and lessons learned for more practical appliance, and in combination a framework can be placed. Hence, the framework is based on theory and presents the theory in a manner that could in turn, via researchers, be accessible to practitioners. It is not as accessible as guidelines and lessons learned, but is on the other hand based on theoretical constructs that can be re-used for a large number of situations. The framework addresses the concerns of the theoretical contributions as well as the guidelines and lessons learned. In a sense, the framework represents the best of theory and craft, and is a suitable way to present the findings of this research to the mobile learning community.

5.4.2 Bringing Forward a Framework

In order to present the findings of the research in this thesis, a framework was formulated that includes all the concepts formulated in the previous section (and summarized in Table 5.2). In order to support the various groups of researchers and practitioners in mobile learning, the framework was created with a focus on the philosophy (cf. Chapter 2), while not focusing so much on the actual tools, methods, and models. There are simply too many such tools, methods, and models to include, and given the diversity it is hard to recommend some before others. Important aspects mentioned previously in this thesis, such as stakeholder analysis and risk management are part of the philosophy of the framework, and will be part of the development of any initiative using the framework. Researchers and practitioners are, however, free to specialize the use of the framework to suit their exact needs by providing their own models, methods, and tools.
<table>
<thead>
<tr>
<th>Stage</th>
<th>Purpose</th>
<th>Outcome</th>
<th>Key Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idea</td>
<td>Establish soundness of the idea</td>
<td>Plan of how to go ahead</td>
<td>Investigate technology&lt;br&gt;Investigate feasibility&lt;br&gt;Surveys</td>
</tr>
<tr>
<td></td>
<td>Establish technical platform</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trial</td>
<td>Test the idea&lt;br&gt;Elaborate the learning&lt;br&gt;Small scale testing</td>
<td>Information about what works and what does not&lt;br&gt;Considerations made on what needs to change in order to move ahead</td>
<td>Produce learning material&lt;br&gt;Offer the learning material&lt;br&gt;Measure how well it is received</td>
</tr>
<tr>
<td>Project</td>
<td>Expand beyond initiators&lt;br&gt;Large scale testing&lt;br&gt;Formalized in terms of resources and outcome&lt;br&gt;Establish social interplay</td>
<td>Information on how the material is received, both in terms of students and teachers experience</td>
<td>Similar to trial but larger scale&lt;br&gt;Report to funding&lt;br&gt;organization</td>
</tr>
<tr>
<td>Release</td>
<td>Hand over to target organization&lt;br&gt;Remove reliance on initiators</td>
<td>Implemented and in use</td>
<td>Integrate into the organization (training)&lt;br&gt;Establish facilities (servers, studios, etc)</td>
</tr>
</tbody>
</table>

Table 5.3: An Overview of the Development Stages.

The framework consists of a life-cycle that divides an initiative into four stages: Idea, Trial, Project, and Release. The purpose and key activities of each stage are summarized in Table 5.3. Each stage is divided into four Areas of concern: Technology, Learning, Social, and Organization. These represent the four major groups of stakeholders as well as the four main sources of risks. The four areas are linked together and depend on each other. A change to one will affect the others. In order to reason about these propagating changes, the concept of Equilibrium is used to reason about the state of a stage. If a stage is in equilibrium, all changes have propagated and the effects of this propagation have been dealt with (or at least considered). Equilibrium is reached for a stage when there is no longer a need for reaction and adjustment.

The concept of Scalability discusses how to evolve from one stage to the next in the life-cycle with the focus on what will change and how to deal with those changes. A large part of scalability is to limit the scope of the change, i.e., to minimize the ripple effects. Scalability means the ability to extend the results from the previous stage and combine them with knowledge of the areas of concern of the next stage. The concept of Sustainability is a means to reason about both an individual stage and the entire initiative. A stage is sustainable if it adheres to the pre-set specification and is in equilibrium. An initiative is sustainable, if the Release stage is sustainable.

In order to reduce the complexity introduced by the areas of concern and the propagating changes, the concept of Focus is used. During each stage of the evolution, one (or at most a few) area of concern is in focus. The area in focus represents the area where the development is currently the most active, and where the direct changes will occur. The other areas are only changed through propagated effects of a change to the area in focus. Focus thus provides a means to reduce complexity and a way to introduce
Figure 5.4: The Life-Cycle and the Areas of Concern.

a sequential work-flow to the framework.

Figure 5.4 depicts the framework and the major concepts. For a more detailed discussion of these concepts and the framework, refer to Section 5.3 or publications IV and V.

By bringing forth a framework that provides stakeholder and risk management as part of the framework, and by presenting a mix of sequential and an iterative life-cycle, that describes the development from conception to implementation (Idea to Release), the researchers and practitioners are free to use the models, methods, and tools that they are familiar with. The major role of the framework is to guide the development practices not to tie down the models, methods, and tools, which follows while the framework is in use. Hence, the framework is there to be a work and communication platform and provide a theoretical take on the information systems development occurring in mobile learning.
Chapter 6

Conclusions

The driving hypothesis that guided the work presented in this thesis is that sustainability issues experienced by mobile learning initiatives are mainly due to the lack of a systematic approach to development. In order to verify this hypothesis and to contribute to the development practice, several studies into mobile learning initiatives were conducted. A substantial number of data sources were investigated and empirical materials were collected using several methods (i.e., the triangulation of methods). The analysis of the empirical materials revealed two major insights. First, as most of the initiatives in mobile learning are research driven (i.e., researchers constitute the core team) and aim to contribute new understanding of mobile learning, the development practice may affect the outcome. Hence, a sound understanding of the development process is important to the research outcome. Secondly, the extended team is populated by a variety of people (i.e., practitioners). These practitioners, including teachers and learners, are often not included in the development process. As discussed in Chapter 2, user participation is important to capture social interactions, which in turn might improve the sustainability.

In order to support researchers and practitioners in mobile learning, the experience and insights gained from the analysis of the empirical materials were used to elaborate and suggest a framework to aid in the process of mobile learning development. This framework includes theoretical knowledge from the field of information systems development combined with practical considerations and concepts found from analyzing practices within the field mobile learning. The empirical material analyzed was gathered from both first-hand experience and analysis of other researchers work, i.e., a triangulation of investigators.

The proposed framework divides the development of mobile learning into four sequential stages: Idea, Trial, Project, and Release each of which consists of iterative development cycles. Each stage is associated with four Areas of concern: Technology, Learning, Social, and Organization, to help reduce complexity and make stakeholder analysis and risk assessment implicit to the framework. The sustainability of a mobile learning initiative is linked to the concept of scalability — the ability to grow according to preset requirements. Focus and equilibrium are two central concepts that are used to reduce complexity and aid in regulating the evolutionary process.
The aim of the suggested framework is to present this information systems development approach in a way that is accessible and useful to researchers and practitioners in the field of mobile learning. By doing so, the framework might be used as a guiding instrument helping mobile learning initiatives to become more sustainable. The next section first looks in retrospective in order to summarize the main results, and then sees forwards to outline research challenges to be addressed in future work.

6.1 Main Contributions

This thesis contributed to the mobile learning research community on three different levels; theoretically, practically, and a combination of those.

The survey of research methods and purposes in mobile learning contributed to a better understanding of how and why research is conducted (Publication VIII). This understanding shows what results can be expected from the different research efforts and how they can be used, as well as what kind of research directions is absent. The results of this survey point out that the research predominantly consists of descriptions of various studies carried out to investigate the use of some mobile learning system/tool. There are few papers that reflect upon the development practice and how to improve it. A small number of the papers were classified as understanding or evaluating mobile learning practices, and even fewer could be considered in the category of basic research.

The investigation into mobile learning initiatives involving members the Kaleidoscope network of excellence (Publication II) studies these issues from different perspectives by using different data sources that together form a unit of analysis. The insights gained from this cross analysis, using different methods and data-gathering techniques (i.e., interviews, questionnaires, literature reviews), contributes with an increase understanding of the problems faced by project managers in mobile learning initiatives. This investigation further applies a risk assessment model (derived from information systems development) to the mobile learning initiatives. The overall outcome indicates that the model can be applied, although experience gained from using it, suggests that the way forward should be a model more suitable to the field of mobile learning.

In order to better understand the initiatives and the development practice of mobile learning, several studies and surveys were conducted. These studies contribute by helping to formulate the framework, i.e., the main contribution of this work, but they also contribute as reflecting objects trying to understand mobile learning practices. Further, in Publication VI a study is conducted which investigates the development of three quite different mobile learning initiatives in order to view how different stakeholders are involved in this process. This is just one example of a cross-case study done to better understand and utilize a number of data sources (i.e., the triangulation of data sources).
Publications I and VII also contribute with lessons learned and practical guidelines that researchers in mobile learning can learn from and reflect upon in order to avoid pitfalls. These can be considered as intermediate steps towards the establishment of the framework, both in development and use.

The originating ideas describing the framework and its development, addressed in publications III, IV, and V, make a contribution in a number of ways. Important concepts within the development practice of mobile learning were identified and connected to relevant theories (i.e., triangulation of theory). This led to the discovery and definition of the notion of scalability in terms of information systems development. Scalability generally refers to the quality to accommodate an increasing number of factors. In the proposed framework, scalability is used to refer to the ability of an initiative to progress from one stage to another. It also refers to the process of changing the scope from one stage to the next, considering all the implications and changes. This makes scalability a key factor in the framework.

Scalability is further linked to the sustainability of an initiative, which can be expressed as having maximum scalability, i.e., the ability to scale to the final stage. The concept of scalability and its relation to sustainability is a contribution on its own. Another contribution of the framework is the way it deals with mediation, i.e., equilibrium and focus. These two concepts together make both risk assessment and stakeholder analysis implicit to the framework.

The main contribution of this work presented in this thesis is the formulation of the framework, and how complex information systems development theories are presented in a way suitable for researchers, and in turn practitioners, in mobile learning. However, the constellation of practitioners in mobile learning is diverse, and for a framework to be useful to the community, it should be understandable and useful to a wide community of systems developers, students, teachers, parents, school administrators, etc. This requires a balance between theoretical concepts and practical considerations, such as the introduction and use of focus and equilibrium to guide the development process.

6.2 Future Research Directions

The framework has been developed on the basis of the experience gained by taking part in mobile learning initiatives, as well as the analysis of a number of data sources. Furthermore, this knowledge and experiences have been related to theories and methods coming from the field of information systems development. As the main efforts of the thesis have been focused on development a framework, it has not been possible yet to use it by researchers and practitioners in the field of mobile learning.

A next step in the coming research would be to offer the framework and its application to a number of initiatives in order to study how they use
it and what feedback they can offer. This should be followed by a more extensive study where the effects of using the framework are investigated. For example, one possible way could be by having several teams working on similar efforts and having some of them using the framework and others not. By closely observing the development processes of all the teams as well as the outcomes, further insights into the applicability of the framework can be gained.

The extended socio-technical model, presented in Chapter 5 and its personal system was created to capture how mobility help make the learning more personal. It would be interesting to study how well this model describes other types of Technology-Enhanced Learning (TEL). These other types might contain some of the aspects referred to as mobility in Chapter 2 and the model might thus prove suitable. This could be studied by reviewing other forms of TEL, such as pervasive or ubiquitous learning, and see how well they fit the model. If there is a fit, the framework could be offered to researchers within those fields.

The framework presented in this thesis could be offered to funding agencies to serve as an aid to help decide what to fund and when to evaluate. The framework could, for example, serve as an indicator as to when the evaluation of a funded mobile learning initiative should take place. The division of the life-cycle of an initiative into four distinct stages could help to decide which initiatives to continue to fund. An initiative that successful reaches equilibrium at for example the Idea and Trial stages might prove more sustainable and a better candidate for funding than one that has yet to start the Idea stage.
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Podcasts as a Supplement in Tertiary Education: An Experiment With Two Computer Science Courses

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Abstract

The current generation of undergraduate students are enthusiastic adopters of mobile technologies, and some of these technologies offers significant opportunities for broadening the times, places and manner that students study and learn. One of these is podcasting, which greatly eases distribution of content to portable devices, giving the students opportunity for anytime, anywhere learning. However, most educational podcasts do not take advantage of the potential of podcasting. In this paper we discuss the issues surrounding the use of podcasting for higher education. We report our experiences using podcasts to supplement two undergraduate Computer Science courses, and we provide tips for others considering the use of podcasts in education.

7.1 Introduction

Podcasting is an asynchronous mode of distributing multimedia files – “podcasts” – over the Internet using syndication feeds, for playback on portable devices and personal computers at the user’s convenience. It has much potential as a highly mobile learning tool, and yet almost all applications of podcasting in university education fail to exploit the potential as they simply broadcast lectures (which are visual and even kinesthetic experiences) as a podcast (which is primarily an audio experience). Some educational podcasts compensate for this by including images, video, and/or web links. However, we believe that there is value in creating audio-only podcasts that supplement the lectures, so that mobile learning can occur in a “hands-free, head-up” mobile situation to enable students to learn also during activities such as commuting.

Despite the audio-only limitation of podcasting, it is attractive for education because it potentially enables students to increase the number of hours of studying without necessarily having to remove something from their schedule such as doing household chores, or exercising. And although we advocate a supplement to lectures, the time required to prepare the extra material in such a podcast need not be too demanding on the lecturer. There are some restrictions on what is possible with mobile podcast listening: the student is not likely to be able to take notes or look up references. A related issue is that it can be difficult to elicit a response because the user may not be in a position to use email or even send a SMS message at the time they are listening, and are likely to forget to do it when they have the opportunity later.

In this paper we review the ways that audio podcasting might be used in an educational setting, particularly in a tertiary environment. We also report the results of experimenting with podcasting as a supplement to two first-year Computer Science courses with approximately 150 and 250 students respectively.
7.2 Podcasting

The normal process for podcasting is that a content provider (podcaster) will make the files available on the Internet via an RSS (Really Simple Syndication) feed, to which the audience subscribes using aggregation software (a podcatcher). When a new podcast is published, it can be automatically uploaded to their portable device and hence they can listen to it at their convenience. Normally subscriptions are free, and there are no direct costs for listening to podcasts. Podcasts are typically provided in a heavily compressed MP3 format and can be played on a wide variety of devices, many of which are available inexpensively. Students are likely to already own something suitable. In addition, any desktop computer with Internet access is bound to be able to play a podcast, which means that owning a portable player is not essential.

Podcasting is a relatively recent phenomenon; the first RSS audio feeds appeared in July 2003 (Doyle, 2005) and by mid-2005 there were approximately 10,000 different podcasts available on a wide range of topics. In June 2005 Apple added podcasting to their free “iTunes” program, and this provided a surge of interest – within two days Apple announced that a million podcast subscriptions had been made. In December 2005 the editors of the New Oxford American Dictionary announced “podcasting” to be the word of the year and it appeared in the dictionary in 2006. Many podcasts have irregular and/or very limited followings, but some have hundreds of thousands of downloads of each episode. Their content and frequency is diverse, from hourly 3-minute newscasts, through daily 20 minute commentaries, to weekly one-hour in-depth discussions. Free software is also available for podcast creation, and there is also a lot of material on the Internet (including in podcasts) explaining how to make your own podcast. For users with an Internet connection, a desktop computer with a soundcard, and a relatively inexpensive microphone, the main additional cost to produce a podcast will be a relatively small fee required to have the files hosted on a server with a plan designed for the large number of downloads that podcasts can get, such as “Liberated Syndication” (http://libsyn.com).

7.3 Using Podcasts in Education

A key benefit of podcasting is that it enables students to listen to course related material while they are engaged in other activities. In the past a highly motivated student might have used such time for revision of their lecture notes, or reading literature references, but the use of digital media players provides a level of portability and ease of file transfer that has not previously been feasible. Also, the use of a feed such as RSS coupled with an aggregator such as iTunes means that the material can be pushed onto the student’s portable device. By having files pushed like this, users are more likely to listen to them because they need not remember to carry out an explicit download.
The medium does have disadvantages, such as the lack of visual content, the difficulty of taking notes, and the divided attention of the listener between environmental distractions and the material on the podcast. Also, the material will be of most benefit to auditory learners, and does not appeal to all students. Despite these limitations, there are many opportunities for using podcasts as a supplement while giving a course. You can use them to give out news and updates, answering questions sent in (for example by email), and/or give general feedback to students. Another possibility would be to highlight the key points you stated in class and have extended discussion about them, and/or conducting interviews with external people adding or reinforcing the material addressed. Podcasts is also a way of providing hands-free instructions to students conducting laboratory work or using different computer programs. In addition we can imagine letting students do project reports using podcast as they develop good oral skills and share their experience with the others. In the wider educational setting podcasting could be used for recruiting and marketing, recording meetings and conference talks, and broadcasting for specific groups such as alumni, sports teams, or cultural groups.

Despite this rich range of potential applications, currently the most common approach to podcasting at universities is to provide the students with the traditional lectures as a podcast. This does have some value, giving them a second, or first if they missed it, chance to listen to it, which is particularly appreciated by students whose first language is not English. In many cases it also means that people outside the university community can benefit from having access to the lectures. However, this does not represent a major advantage over existing lecture recording systems that publish the audio or even video on the web.

**7.4 Podcasts at Other Institutions**

A number of institutions have started to offer podcasts. Duke University’s “Duke Digital Initiative” was one of the first institutional experiments with ubiquitous portable audio devices, when in August 2004 all of the first-year students were given a 20G iPod to use as a learning tool (Duke University, 2005). The intention was to facilitate innovative use of technology on Campus. Applications that emerged included course content dissemination, classroom recordings, field recording, study support and, file storage and transfer. The students found the iPods useful for study support by using them for repeated listening, audio books, going over rehearsals (drama and music), and vocabulary lists. However, there were relatively few Podcasts (three podcasts were reported after the first year), and it appears that the major educational use was more student-driven: 60% of students reported using their iPod for recording material, and 28% for music and hard drive storage. A total of 75% reported using it to support their learning.

A number of universities have started making some of their lectures avail-
able to the general public through podcasting. For example, Harvard is into the second year of podcasting their course “Computer Science E-1, Understanding Computers and the Internet” (http://www.fas.harvard.edu/~cscie1/), and it has many followers – it has appeared in iTunes’ top 100 Podcasts. Berkley University has among 30 faculty members who have agreed to clip on a microphone in class so that their courses’ audio can be recorded and then posted online (http://itunes.berkeley.edu/). Princeton University’s University Channel (http://uc.princeton.edu) let different universities contribute recordings of lectures, seminars, panels and interviews to a virtual pool of academic content under their own name.

The public podcasts of lectures allow anyone to sit in (“audit”) a course, albeit without the full student experience. Access to these lectures in a mobile environment is valuable for the casual listener, and particularly for other educators who can pick up pedagogical ideas by listening to another teacher at work. This open-source ethos is to be applauded, and reinforces the idea that institutions should control qualifications, not the knowledge itself. It can also improve the quality of the education since the teacher is exposing their teaching to such a wide audience, increasing the opportunity for feedback.

University of Southern California had two 2006 spring courses with lecture podcasts being evaluated and according to Wolff (2006) the outcome was positive in both cases. However the reasons differed as one course had a large number of students for whom English is a second language who listened to the whole lectures again, while the participants of the other course valued having the recording to replay specific explanations to understand difficult material.

From an online survey for the podcast pilot in 2005 at University of Washington, Lane (2006) reported that 70% of the students found that podcasts supported their learning and to be helpful when preparing for homework and exams. The response rate was low, 41 out of 148 enrolled students completed the voluntary survey, but can indicate the perceived value of podcasts. Interestingly, 81% of students used a desktop computer rather than a portable player to listen to their podcasts. It appears that when listening to a lecture podcast, it is valuable to sit at a desk and use notes and handouts, in which case a desktop computer provides a better interface for listening to audio than a portable device. This reinforces our contention that simply podcasting lectures does not take full advantage of the potential of podcasts to facilitate mobile learning, and for this application learning may be better facilitated by using tools such as the Audio Notebook (Stifelman et al., 2001) and AudioGraph (Jesshope, 1999), which provide a richer capture of the lecture.

Furthermore, making lectures available in a flexible manner can potentially inhibit learning. Students can postpone listening to lecture material indefinitely. In an earlier experiment with video-recorded lectures, we observed exactly this behaviour: once the video-lectures were made available, attendance at lectures dwindled because the students could catch up
through the video at any time, but they never realised their intention to do so (Bell et al., 2001). This is not likely to be a problem for motivated students (e.g., for mature students and/or professional courses which could benefit greatly from this mode of getting lecture material), but for less mature students we suggest structuring curriculum delivery in a way that encourages them to keep up with the class schedule.

7.5 Podcasting Experiment

To evaluate the potential of podcasts as supplementing lectures, we ran a podcasting experiment for two first-year Computer Science courses, COSC122 (“Algorithms”) and COSC110 (“Working in a digital world”), at the University of Canterbury, Christchurch, New Zealand. Approximately 150 and 250 students were enrolled in the courses respectively. We released weekly podcasts that supplemented the lectures rather than record them in their entirety. We did, however, also provide three recorded lectures for each course, without announcing our intention to do so, to see whether students would take the opportunity to review the material.

At the start of the COSC110 we surveyed students to determine what sort of access they had to digital audio players, and if they had any experience with podcasts. We found that 64% of the students had a portable device, and that 82% regularly listen to audio on a computer. Those that had portable devices estimated that they spent an average of 7.6 hours per week listening to them, and 16% reported listening to them for 10 or more hours per week. The most popular situation for listening to them was while walking (33%), but other activities are popular too, including on the bus and in the car (21% each), while exercising (15%) and on a bike (10%). Only 13% of the students had listened to a podcast before, and only 3 students in the class reported listening to podcasts daily. This is likely a reflection of the lack of adoption of podcasting in New Zealand due to relatively high charges for Internet use. Despite the lack of experience with podcasts, 87% of the students reported that they intended to listen to the first podcast.

The initial survey also asked students to report their level of interest (5-point Likert scale from 1 for not interested to 5 for very interested) for three types of material in the podcast. The number of students showing an interest level or 4 or 5 (i.e. more than neutral) was 50% for recordings of lectures, 72% for summaries and extra information, and 65% for topical issues relating to the course, indicating a student preference for the supplements, although the inevitable demand for re-runs of lectures.

Both courses were given weekly podcasts. The COSC122 podcasts were about 20 minutes long, with one presenter, while the COSC110 podcasts used two presenters, and ranged from 15 minutes to almost one hour. The entire fourth podcast of COSC122 is accessible as an example at http://www.cosc.canterbury.ac.nz/tim.bell/podcastExample.mp3. The COSC110 podcast was made available to the public through http://uccsse.
For both podcasts, the general format was to review the material from the past week, discuss topics coming up later in the course, remind students about any deadlines and provide discussion about current topics, especially if they related to current events. Each COSC122 podcast had a competition with a small prize to encourage students to email in their comments. In one of the COSC122 podcasts a section of the course textbook was read aloud (with some additional commentary).

The podcasts were recorded using digital audio editing software, with a studio microphone. Off-site interviews were recorded with a portable digital audio recorder, although there are many other devices including mobile phones, laptops and digital cameras that could be used for this. A theme tune was used to add interest, provide context, and give personality to the podcast. It was also useful for covering background noises such as pages being shuffled. Interviews were edited into the podcast – in fact, many of the COSC110 interviews were recorded as one of the authors traveled around the world, which demonstrated truly mobile teaching with several interviews recorded on a conference on a ship on the Yangtze river, as well as commentaries recorded while waiting at airports. Although intricate editing is possible with the software we were using, the podcast genre typically has a “live” style, with minor glitches left in the recording. Recording in one take makes creating the podcast much less effort, and gives a personal and dynamic feel to the episode. Podcast recording software such as “Castblaster” and “PodProducer” assume this one-take mode of operation, whereas editing systems such as “Audacity” and “Garageband” encourage the podcaster to edit the content. We found that interviewees were often a little nervous as it was a new experience, and in these cases the offer to edit out any hiccups was greatly appreciated. Generally very little editing was needed once the interview got underway.

For COSC122 we were able to compare actual downloads with the students’ expectations in their survey. Unfortunately in the first week of term a major server crash occurred that made access to the podcasts very difficult for students. However, in the second week when the system was working properly, the second podcast was downloaded 69 times, which compares favourably to the 87 students who said they intended to download it, although it represents just under a half of the class, and we were unable to count unique downloads. The three lectures were downloaded 37, 33 and 33 times each, which is under half the download counts for the first five podcasts (50, 76, 35 (missing data in the logs), 79 and 73).

The COSC110 podcast was made available to the outside world through iTunes, and the number of downloads often exceeded the number of students in the class. Feedback from outside listeners included one ex-student who was using the podcast to catch up with developments since taking the course.

Feedback and Summary Questionnaire: We were keen to receive feedback from the students to gauge the podcasts’ effectiveness and to help us tailor future podcasts to better suit their needs and desires. We tried a variety of
techniques to encourage feedback, including a draw for free coffee for students who emailed or text-messaged us to say they had listened. Response rates to the draw were very low, with only two to five responses per week, but low response rates are a known phenomenon for podcasts, even when they are heavily downloaded. One explanation for the low response rates is that listeners are often occupied with other activities (such as walking, cycling and driving) making it inconvenient to respond on impulse. The few responses we did receive were generally positive. Giving answers to student questions in the podcast was well received, and the summaries and extra information seemed to be the most valuable. Reading from the text book drew one unfavourable comment despite it representing a genuine time-saving for students who intended to read the text anyway. Some students asked for all lectures to be made available, although we chose not to for the reasons given earlier. Some students worried about the cost of downloads, although in fact we had set it up so that it would be free.

After five weeks of podcasting COSC122 (including the three sample recorded lectures), we administered a questionnaire in a regular lecture to gain insights into the extent of use of the podcasts, the students’ on-going intentions, and their perceptions of the podcasts they had listened to. 56 completed surveys were returned — approximately 38% of the class. Of those, 37 (66%) reported that they had not downloaded any of the podcasts. The most common reason given for not downloading the material was that they “still plan to” (16), and that they had problems accessing the podcasts from home (13). Four stated that they “were not interested”, five stated that they forgot, and six stated they had “technical problems”. This suggests that if we overcame technical problems and made it easier for students to remember to download then the number who used the podcasts could more than double, and the majority of the class would be listening to podcasts. This is likely to be the case as the technology matures.

Nineteen participants (34% of responses) stated that they had downloaded some or all of the podcasts. Of the five podcasts, most people listened to all of the material, except for podcast 2, which had a higher ‘switch off’ rate. This is unsurprising as podcast 2 included the relatively long (8 minutes) reading from the text book; but it shows that students’ tolerance for “dull” podcast material is relatively low.

We asked five questions regarding the problems that they had encountered with the podcasts, again rated on a five-point Likert scale from 1 (major problem) to 5 (no problem): remembering to download, remembering to listen, quality of audio, finding a device and getting distracted. Of these, remembering to download was the biggest problem (mean 3.5, s.d. 1.5), followed by getting distracted (mean 3.7, s.d. 1.2) and remembering to listen (mean 3.9, s.d. 1.0). Neither quality of the audio (mean 4.7, s.d. 0.6) nor finding a device (mean 4.4, s.d. 1.2) appeared to be a major problem for these respondents who had successfully accessed the recordings. The relatively high problem rating for getting distracted is a concern, particularly because students may be listening to the lectures while carrying out
activities such as cycling and driving.

The COSC110 class used a different format, with a 2-person discussion which usually went for 30 to 60 minutes. Informal feedback from students indicated that this is too long for many, and that the podcast should be kept short and to the point.

It was clear from the feedback that there is a small but significant group of students who have almost no interest in this mode of learning, but those that regularly used the podcasts the feedback was extremely positive, including comments such as “Great – keep it up!” and “Nice addition to study kit”.

7.6 Conclusion

These experiments with podcasting indicate that it can be a low-effort and effective supplement, but not substitute, for traditional lecture-based courses. The students who used our podcasts greatly appreciated them, and many of those who had not yet accessed the recordings indicated that they thought it was potentially useful and interesting, and that they intended to access them “later”.

A number of suggestions for podcasts content are given earlier in the paper. In the light of our experience we offer the following tips for those considering using podcasts to supplement introductory undergraduate courses:

- Keep podcasts short and to the point – 15 minutes per week is probably about right for most students unless the podcast is expected as part of the contact time for the course.

- Use a system such as RSS to push the information out to students; this is likely to result in a higher uptake than if they students have to manually download the files.

- Be aggressive in overcoming technical problems at the start, such as making sure files are easy to download both on-campus and at home.

- Include motivating material in the podcasts such as interviews and topical news articles.

- Maintain a live feel to the podcasts, and inject personality. Recording the podcast with minimal editing dramatically reduces the work for the producer and creates a dynamic mood for the episode. Apart from the initial overhead of setting up the recording system and background music, the time taken to produce a podcast will not be much longer than the podcast itself.

- Do not be surprised or concerned about low response-rates to requests for feedback in the podcasts. This is a known phenomenon for the podcast medium. Based on our experience, podcasts seem to be an attractive tool to help engage students, build a class “culture”, and disseminate the important and fascinating problems that the discipline addresses.
If you are podcasting recordings of lectures, students are more likely to be listening to them in a non-mobile situation because of the length and to avoid the distractions of a mobile environment, in which case you should consider posting other course materials online as most students will be at a personal computer and can make use of links to other references.

We hope that we will see more podcasts that supplement courses rather than just take audio content from lectures, as we believe that this adds considerable value, and need not be onerous to produce. This could range from a cognitively demanding podcast such as teaching a language, through to lighter material such as interviews with practitioners that can be followed despite the distractions present in a mobile environment, giving a good return to the student for a relatively small investment of time and effort.

Bibliography


URL: \url{http://cit.duke.edu/pdf/ipod_initiative_04_05.pdf}


Publication II
Publication II

Thinking Ahead in Mobile Learning Projects: A Survey on Risk Assessment

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Abstract

Mobile learning is an innovative and dynamic field of multidisciplinary research and development. This paper presents a study of risk assessment in mobile learning. Interviews, a questionnaire, and several publications are used as means for data collection. This is done to identify risks within mobile learning projects in order to investigate how well these fit a risk assessment model for socio-technical systems. The survey of mobile learning projects show that the project managers are faced with an array of potential risks. The risks are then classified according to a model developed by Lyytinen et al., which is based on the influential Leavitt’s Diamond. The research finds that the model is sufficient to classify the risks experienced by mobile learning projects. It does provide a good starting point and when used it can quickly illustrate how the variables relate to each other. The complexity concerning risk management is important for the mobile learning community, and a model to proceed from might benefit the community greatly.

Keywords: mobile learning, project management, risk assessment, socio-technical system

8.1 Introduction

The prevalent understanding of mobile learning is that it is learning on the move, often enabling the learner to take control over time and place, making it more spontaneous and personal according to Kukulska-Hulme and Traxler (2005). Naismith et al. (2004) suggest that using the time when a person is mobile is a way to tap into a resource maybe not optimal used or used at all before. A learner do not have to be on the move per se, just being without the need or ability to access static learning resources (e.g., libraries, desktop computers, textbooks, etc.) is sufficient as criteria to be called mobile learning, as stated by Sharples (2000). The uncontested definition of 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 learning opportunities offered by mobile technologies”, from O’Malley et al. (2003).

As the current mobile and wireless technologies have reached a level of maturity and ability to support a variety of learning activities, the amount of projects within the field of mobile learning have steadily been on the rise. These projects are faced with, and need to deal with an array of problems to meet the challenges presented when populating such an innovative and dynamic field. Mobile learning is by definition a multi-disciplinary field, spanning across Computer Science, Educational Studies, Information Systems, Project Management, Software Engineering, etc. Along these lines the outcome from these projects can be called mobile learning systems, and
these should be labelled as socio-technical systems, i.e., open systems considering people and technology together and focusing on the interactions between them.

These interactions are something the project managers in mobile learning need to master in order to become the anticipated success they are expected to be. Järvelä et al. (2007) remark that “only a few studies give detailed arguments as to what are these new opportunities in terms of learning interactions and collaboration and what are the exact processes that mobile tools can scaffold.” Hence, to this day, few of the mobile learning projects resulted in actual learning aids that are in wide use, as observed by Keegan (2005). It seems they are being fazed tackling issues along the way. These issues either affect the development, for example by making it more complex, more costly or take longer time, or affect the outcome of the project in ways that make it unsuitable for the intended learning purpose. For example, in several projects the development has been affected by technical limitations, when environmental impacts such as weather or vegetation made the tools difficult or impossible to use, or ended up with technical solutions that do not fit the intended organization’s infrastructure.

The unforeseen events encountered by mobile learning projects are in essence the same as risks in information systems and software development. Here, the term risk is used to refer to unsatisfactory outcomes, such as budget overruns, wrong functionality, poor quality, etc. (Boehm, 1991) and a failure to obtain all or any of the benefits (McFarlan, 1981). Risk management deals with how to assess and control risks, and has been the focus for much investigation. Various fields have contributed and presented several theoretical models and approaches to deal with risk management for example in Information Systems and Software Engineering.

The research presented in this paper focus on risk assessment for mobile learning projects. There is little research on the area within the field of mobile learning, and the aim is to investigate how risk assessment in itself for mobile learning projects could be improved. A number of projects are studied in order to find the risks experienced. There is a reason for this. The reason is to investigate if a risk assessment model for socio-technical systems is suitable for mobile learning projects.

The rest of the paper is organized, following this introduction with Section 8.2, discussing risk assessment and the adherent social-technical model. Section 8.3 describes how the empirical data was gathered, continued with an analysis of the empirical data in Section 8.4, which is followed by a discussion in Section 8.5. And Section 8.6 concludes the paper.

### 8.2 Background

Mobile learning as a research field is characterized by constant technological change and innovation. Naturally, researchers are one step behind with theoretical development from the fact that they are first being practition-
8.2 Background

As practitioners, they learn by doing, rather than thinking behind the desk or desktop. Therefore, risk assessment in the field of mobile learning is currently presented as guidelines based on the trial-and-error conduct and the emergent know-how from a practitioners point of view, for example Vavoula et al. (2004). Risk management is a tough, practice-based problem area where the experiences of project managers are important and the context is of essence. Traxler (2007) states that it must be recognized that mobile learning is essentially personal, contextual, and situated; this means it is ‘noisy’ and problematic area of research, and few projects are completed to further implement and evaluate these experiences. This means that the field of mobile learning should be moving from techno-centric to managerial questions, and consequently it is of high interest how valuable insight can be gained from investigating contemporary conduct on how risk, context, and innovation interact.

Lyytinen et al. (1998) state that in order to control risk there is a need to acknowledge the setting as socio-technical, and continue with presenting a schematic division based on Leavitt’s open system model of organizational change to frame the potential risk areas involved. Leavitt (1965) views organizations as systems consisting of four interacting variables, these being: Technology, Task, People (Actors), and Structure. The four variables are highly interdependent, as indicated by the arrowheads between them, depicted as the classical diamond shape in Figure 8.1. These arrows indicates a strong bond and that a change to one of them will affect, no matter planned or unplanned, the others.

Change in itself is inevitable for any socio-technical system and the model uses the concept of equilibrium to reason about the interactions between the variables and its stability as a whole. If the state of a variable is incompatible with one or more of the others, it will affect them and result in compensatory or retaliatory action from the others, and hence shape the performance of the entire system. The effects of an incompatible variable are called variations in socio-technical theory, according to Mumford (2003). The aspiration of any project manager is to identify and control such variations,
maintaining the system equilibrium either by enforcing routine or planning of problem-solving measures. Changes can cause variations, and variations can in turn cause failures when not dealt with correctly. The variations can be considered risks. So, there is a great need to understand the extent, impact, and nature of these risks, as well as the potential insights and solutions.

In the opinion of Lyytinen et al. (1998) aiding in the work behind risk assessment, the conception of the four variables individually and their interaction with one another can help. The notion that these interactions sometimes cause them to collide can also prove helpful. In light of this, the variables can be considered the tectonic plates of risk assessment. The four variables on their own form a good initial picture of the possible risks. However, several risks can exist within the interdependencies between the four variables as well. Following is a description of the four variables and each of the possible six combinations, provided together with examples related to mobile learning projects. These are provided to illustrate the reasoning and connection between the variables.

The first tectonic plate is Technology. It refers to direct problem-solving inventions, which for example include methods to develop and evaluate, as well as the methods used within the system. It also includes the actual tools, such as the infrastructure platform used. In a mobile learning project, Technology includes the mobile devices, the server hardware and software, pedagogical theories, etc. Technology can be the source of considerable risk, for example if it is non-standardized, unstable, or have functional limitations.

The second tectonic plate is Task. It is the production of goods and services, including the large numbers of different but operationally meaningful subtasks that may exist in a complex organization. It describes the reason for the existence of the project, i.e., the main goals and purpose. This is normally defined by deliverables and process features. In terms of mobile learning projects, the task is often a learning scenario, which describes how the learning can be conducted using technical aids. Observed risks are complexity, size, and ill-defined or unrealistic goals.

The third tectonic plate is Actors. It refers chiefly to people, but with the qualification that acts executed by people at some time or place need not remain exclusively in the human domain. In short it portraits the stakeholders of a mobile learning project. Risks that are connected to actors are for example false beliefs or wrong expectations, staff lacking in skill, and unwilling users.

The fourth and last tectonic plate is Structure. It means systems of communication, system of authority (or other roles), and system of work flow. It includes both norm and behavior, i.e., roles, values, and actual patterns of communication. In mobile learning projects, this can include the structure and roles in learning, the authority of schools and government, and similar issues. It also includes the development process. Risks involve a lack of communication with, for example intended users or bad planning.
The interaction between the four individual variables are also interesting and continuing in turn with the crossing path of Technology and Task. This focus on how technology fits with the task. Misfits between these two can create considerable risks. Problems with, for example, too complex and sophisticated technology can increase the task complexity making it hard, if not impossible, to perform. This type of usability testing should be identified at an early stage when these can be easily corrected, whereas changing a product after deployment can be costly and not always feasible. Considering the mobile learning project as part of a socio-technical infrastructure means to develop learning activities using the technology and that the technical system must be seen as part of those activities and not a separate product.

Next, the junction of Technology and Actors zooms in on the relationship between the technology and the people, for example problems associated when attempts are made to introduce untested technologies or technology that do not suit the users. For mobile learning, there exist a need to fine tune the perception of and not get blinded by the innovations of new technologies and ways technology is being or can be used. Careful consideration of pedagogical design, keeping the position of the learner in mind and embedding technology in a pedagogic surrounding is the key.

All while, the meeting point of Technology and Structure deals with the interaction between technology and the organizational structure. Inappropriate technology can cause considerable disturbances and even be in conflict with authority and communication lines. Considering the organization (and society) and technology as closely connected is advocated for mobile learning. For example, recognizing and even encouraging learning that takes place outside of the classroom, the need for formal learning to intersect with different modes of learning that take place through technologies in informal settings outside the school is needed.

The intersection between Task and Actors puts attention on the actors abilities relating to the task, for example their ability to specify, analyze, and carry out the task. Risks here include actors attitude and understanding of the task, for example the experience or disagreement of the purpose of the task. This is evident in mobile learning, where most studies have either provided evaluations in the form of attitude surveys and interviews, that stating learners say they enjoy it, or observation based, where learners look as if they are learning. These kind of results do little in terms of providing evidence that learning has occurred, its features or durability. Although surveys, interviews, and observations can illuminate the learning process, more is advocated to manifest the fit.

The match of Task and Structure revolves around the fit between task and the organizational arrangement. Misfit can cause risks, such as unbearable workloads, ethical dilemmas, and inadequate use. When introducing technologies and services for mobile learning, there is a need to apply a comprehensive approach considering the individual, social, and organizational aspects of technology adaption for the task of learning, and not purely focus
Lastly, the Actors and Structure coordination focus on the interaction between people and the organizational constitution. A disarray in for example stakeholder behavior, incentives, and locations, towards the prevailing integrity could cause risks. In mobile learning this is illustrated by the overwhelming nature of the social and cultural context in which new technologies are trialed. This is leading to the importance of trying to fast track the development so that the technology is used by real people in real setting as quickly as possible, in order to be able to perform critical incident analysis. This can be for example done via reflective interviews with stakeholders.

8.3 Method

This section presents the method and specifies how the data collection used multiple means, offering the opportunity for triangulation of the same, as specified by Robson (2002). Prior to data collection the research objective, in the form of a research aim was proposed, and led to a focused approach in getting to the unit of analysis (Yin, 2003). A number of questions were thought out (information and experience related questions to project managers on their latest completed mobile learning project) and in March 2008, phone interviews were conducted with three project managers as to survey the problem area as such and in particular the questions. This was done to get input on how the questions were perceived and answered, and to construct a questionnaire from the insights gained. Next, the link to the electronically posted questionnaire was sent out via e-mail in April 2008, to all the 30 project managers specified on the Kaleidoscope homepage (Kaleidoscope, 2009) together with an introductory text specifying the reason for it, who was asking, and that their participation would be much obliged. They were given a three week window to complete the questionnaire.

Kaleidoscope is a European research network of excellence, consisting of more than 1000 researchers from over 90 research centers. The aim of Kaleidoscope is to transform the quality and reach of the learning experience and build a sound foundation for Technology Enhanced Learning (TEL). The research conducted within the network is primarily based on experimental field studies and in turn providing theoretical contributions from these. The choice of Kaleidoscope as a convenient one as it is an umbrella organization for mobile learning in Europe. It is also an appropriate choice to use as to gain access to the unit of analysis via the first author’s association to CeLeKT (Center for Knowledge and Learning Technologies) at Växjö University, Växjö, Sweden, which is one of the contributing parts of the Kaleidoscope network.

The choice of Kaleidoscope was made to gain insight from project managers in the field of mobile learning, representing a specific data set but still with experiences from a range of diverse settings and hence views on risk
8.4 Analysis

This section presents an analysis of the questionnaire and the publications listed in the questionnaire. First, the answers to the questionnaire are presented and analyzed, then these answers are classified according to the model presented in Section 8.2. Based on this, the publications are then analyzed and problems found are categorized according to the same model. This way, the risks experienced can be tied to actual instances and problems, together with indications of how problematic these were. The analysis will focus on the questions regarding risks related to mobile learning, not the identification questions, such as name, project name, budget, etc. (i.e., questions 1 to 7).

The questionnaire (cf. Appendix A) has two categories of questions. The majority of the questions use a Likert scale with three options – I agree, I agree to some extent, and I do not agree. The answers to these are summarized in Table 8.1. The rest of the questions are open (free text). Although, some do provide a set of elective options to choose from (listed within brackets) for inspiration. The free answers are addressed in connection to the question posed and often in quotation marks. A publication is referred to by the symbol # and its number (cf. Appendix B). Some direct quotes are given as examples from the publications to highlight the problem area.
Questions 8 and 10 focus on the learners and their interactions with the mobile devices, and the answers to these questions show that the perception of the learners were that they were willing to participate in the learning activities (100%), and a majority of them did not experience any major difficulties using the technology (81.5%). To further illuminate these issues, from #9, it can be noted that “students pointed out that listening to the lecturer, writing lecture notes and using the mobile learning tool at the same time, were too much to handle. Therefore, aspects related to cogitative load need to be recognized.” #3 made the observation that “listening to a lecture, following a displayed presentation, making notes and exchanging them with colleagues all at the same time is challenging even for the most skillful students.”

Further, in #13, “student ownership and 24/7 access to a handheld device is central to the approach”, and further along this line “where students had constant use of the mobile devises, there was evidence of a growing sense of autonomy, as students created their own uses to meet personal purposes”, addressed in #7. From #22, the need to “ensure security and privacy for the users” is perceived and in #4 “users can switch to private mode (invisible) but still can utilize the system resources”, while in #23, the “access to the webspace is password protected, and the content published by the students is moderated to ensure privacy protection and appropriate use.” #3 state that “technology is only a means to an end, a more productive, active, engaged and motivating learning experience for the learner”, similar to #6 where “ICT (Information & Communication Technology) is seen as an enabler, rather than an end in itself.”

Question 11 shows that most project managers think that educators agreed with and saw at least some benefits of the technology (37.5% agreed, 50% agree to some extent, while 12.5% disagree). This notion is approved by #12 where “looking at the design related issues, the two teachers en-
joyed being involved in the design of the activities as well as in the process of creating new learning materials. They also experienced that this type of ubiquitous learning activities may work out best when there is a proper balance between pre and post activities combined with field trips.”

From Question 21, a majority of the projects, 80%, were initiated within the project team. This is supported by #7 which state that “although the project was not initiated by the teachers, they seemed to be pleased with the technology.” In light of Question 12, 40% of the project managers agree that there was a lack of operative support from the partners of the project. From #20 it is expressed as “the service is costly and museum representatives have expressed concerns about the running costs of the service, including staff time, and resources.”

From Question 9, it can be noted that 62.5% state that there was some difficulty in communicating with key partners. The complexity behind this is shown in #24 where “the stakeholders included the funding body, the development team, teachers, LEA (Local Education Authority) representatives, and museum curators and educational experts.” Moreover, this complexity is recognized in #27 “for effective deployment of mobile devices in teaching and learning support there needs to be recognition of PDAs and smartphones as part of the ‘whole’ ICT system within an institution” and in #22 where they acknowledge the need to “provide training and on-going technical support to the teachers to enable them to use the mobile technologies to enhance current and enable new learning activities.”

In regard to Questions 19 and 17, 75% agree that the settings where the project took place were more complex than expected, and 81.5% agree that the goals of the project changed as the project progressed. This contingency is clearly visible in #16 where “results also suggest that in higher education, the challenge is on designing for social technologies that allow for bridging different pedagogic goals (control of learning) and ways of communication between the different actors in the learning environment” and “these latest aspects require more than designing just services to connect people and content, but also creating new didactic sequences and educational activities that connect formal and informal learning settings.”

From Questions 14 and 15, all project managers agree that the team had the necessary knowledge to complete the goals and that there was a clear division of responsibility within the team. In contrast to the answers, it is stated by #6 that a team should consist of “educators, educational researchers, educational psychologists, designers, and technologists”, and this continue in #22 where the need to “assign or assume necessary roles for initiating and supporting mobile learning - a combination of teachers, technical experts i.e., multidisciplinary teams, and educational visionaries is necessary to ensure that the resulting applications are appropriate and effective in the schools context”, is noticed. In #24 the work appraisal changed and “care is needed not only in designing the technology, but also in designing the learning task that takes use of the technology... it had to go beyond the technology to look at the learning experience as a whole.”
When asked to elaborate on the issues regarding for instance the partner organizations (Question 13) one project manager states that “Schools were very used on a way of doing things – it was difficult for the teachers to introduce new technologies.” The same project manager also cites the school culture of mobile phone bans and locked down networks as a problem. Another project manager points out the importance of recruiting teachers to the team rather than administrators, and the value of co-design. This is corroborated in #6, stating that there exists a “realization of the importance of technology but inability to incorporate this due to lack of training, adequate infrastructure, and integration with the current curriculum.” Further, in #25 “a significant problem facing MyArtSpace for wider adoption was the additional load placed on the school and teachers.”

In Question 16 the project managers were asked what advice they can offer to others, and a majority of the answers relate to project organization, i.e., clear goals for outputs, good documentation, communication and information flow, as well as the importance of supporting partners. One project manager gave the comment: “we could not claim from the teachers to get involved 100% when they did not get specific financial support to participate in the project.” Another comment was to “prototype early on so that the stakeholder understand what you are trying to accomplish.” This is also addressed in #25 where a museum staff member is quoted “We would like to have continued with the service but it is not financially viable for us within our current budgets. We would only consider continuing with MyArtSpace if it could be funded again.”

Evaluation was the topic of Question 20 and 93% of the project managers agree that it was difficult to assess the learning outcome. In light of this #8 points out that “it has also become evident that successful collaboration is not a spontaneous phenomenon, but structuring and regulating socially shared learning process is needed.” “Furthermore, the use of the mobile lecture interaction tool supported students feelings of belonging to a group” as pointed out in #9. From #11 it is also stated that “the task of designing effective computer support along with appropriate pedagogy and social practices is more complex than imagined.”

In regard to Question 22, over 60% of the project managers state that usability was the focus of the evaluation. Almost all of the evaluations were done by the project team – only one project manager says that outside
experts were used. However, many of the project managers claim that the team had access to evaluation experts within the team.

When asked which aspects hindered the running of the project (Question 25), the most common reasons were: limited time (53%), technical issues (41%), and limited budget (35%), while stating access to educators or an unstable setting were 17.5% each. Additionally, due #13 and #22, it can be seen that the “future success of mobile learning in school settings will depend on the preparedness of teachers to adopt mobile technologies in the classroom,” and “consider the use of mobile technologies to support collaborative and group learning, while also discover and adopt suitable applications to match the needs of a specific classroom and map directly to curriculum needs.”

The questions of the questionnaire focus on which risks the project managers experienced, and Table 8.2 relates these questions to the risk assessment model discussed in Section 8.2. A majority of the risks relate to the variables of Actors or Structure.

Based on the results of the questionnaire, the given publications were read and then analyzed. Risks and problems mentioned were classified according to the risk assessment model and the result is presented in Table 8.3. When analyzing the risks experienced in the publications, the picture is enhanced and complements the one presented by the questionnaire. Technology risks are prevalent as are risks in the relations between the other three variables. On the other hand, the risks that were the most prevalent in the questionnaire, i.e., the ones relating to Structure are less common in the publications. The most common risk categories are Technology and Task-Actors. Of the 28 publications analyzed, 10 (36%) fall into each of these. These two are followed by Task with 25%, and Actors-Technology, Actors-Task, and Actors at 18% each. Actor-Structure risks are only experienced by 4% of the publications.

8.5 Discussion

From the risk assessment model suggested by Lyytinen et al. (1998), which is based on the seminal work on organizational change by Leavitt (1965), an analysis of the gathered data was made in Section 8.4. The data consisted of a questionnaire, especially targeted for project managers in the field of mobile learning, and their corresponding publications. The given answers were classified as were the risks pointed out in the publications. The model could capture risks extracted from the questionnaire and publications. This shows that the model is expressive enough to use for mobile learning, and suggests that it could be used to identify risks. It can also be used to analyze risks and classify these after the fact.

The idea to have not only the four main variables; Technology, Task, Actors, and Structure – the tectonic plates of the risk assessment – but also the interactions between them proved powerful. A project manager
Table 8.3: The Risks Addressed by the Publications and Their Numbers.

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analyzing the potential risks cannot consider Technology alone and then move on, but must also consider Technology and its interactions with Task, Actors, and Structure. The analysis of the publications shows that many risks were found in the interactions between the four main variables.

However, generally the power of a model is closely related to its complexity - the more complex it is, often the less functional it is as a tool to use. This turned out to be true for the risk assessment model. Finding and classifying risks related to the main variables turned out to be quite demanding, mainly because a risk seldom relate to a single variable. The more intricate risks often quickly relate to all the variables and put stress on the implications of these interactions. For example, Hartnell-Young (2007) discusses that the use of mobile devices blurs the time and space for learning and has both positive and negative implications, e.g., parents could engage in virtually attending their children’s away weekend with their class but if one of the goals of the experience is for students to practice independence it can be contradictory in terms. This could lead to greater control and surveillance of the students, meaning the school communities need to make appropriate and sensible decisions about such issues. This example clearly manifest how Technology (i.e., mobile device) points to the Task (i.e., learning goal), then Actors (i.e., parents), and finally Structure (i.e., policy).

Given the complexity of risk assessment, several lists of competencies for proper assessments and common risks have been published within Information Systems and Software Engineering, to help project managers to at least consider the most desired capabilities and the most previously noted risks for systems design in general. For example, Mumford (2000) lists the capabilities needed, specifying knowledge, resources, psychological, organizational, and ethical, while Boehm (1991) presents the top ten risks
of software development and cites “Personnel shortfalls”, and “Unrealistic schedules and budgets” as the top risks. Many of the qualities and risks discussed by Mumford and Boehm are still valid for mobile learning, however there is also need for a set of domain-specific ones.

8.6 Conclusion

This paper presents a study on risk assessment in mobile learning in order to better understand what risks there are and how a model as an underlying construct can help project managers to identify them. Hence, a questionnaire and a number of publications were analyzed with respect to risks. These risks were classified according to a risk assessment model for socio-technical systems, suggested by Lyytinen et al., on the basis of Leavitt’s diamond structure on organizational change considering four variables: Technology, Actors, Task, and Structure.

The model proved to be useful but demanding, and not ideally suited for mobile learning projects. The complexity stem from that the model regard interaction between the variables as discrete, which often leads to cyclic dependancies. This conceptual roundabout is very valuable on a meta level, but at the same time difficult to connect to use in practice. Another issue with the model is that the names given to the variables are too general, making them hard to relate to, and not directly suited for the multi-disciplinary project managers and teams populating mobile learning projects. So, to improve the current situation based on the findings of this research, the model should be simplified with respect to the interactions. Moreover, it should be adjusted to mobile learning by a slight redefining of the four variables and offer a distinct priority order. This could then serve as a help for project managers and their teams in mobile learning when dealing with the development process as such.

Acknowledgments

The authors like to take this opportunity to thank fellow colleagues Jesper Andersson, Welf Löwe, Marcelo Milrad, Anita Mirijamdotter, and Thomas Panas for their comments on the research leading up to this publication. We also want to extend our gratitude towards Mike Sharples, University of Nottingham, for encouraging and practical feedback on the questions when the questionnaire was under construction and later sent out.

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A. Questionnaire

1. Please state your name
2. Research group
3. Project name
4. Team size (in number of people)
5. Funding agency/agencies
6. Budget (in Euros)
7. Project duration (in months)
8. The learners were enthusiastic while participating in the activities
9. It was problematic to communicate with key persons from the partners involved in the project
10. The learners effortlessly used the mobile technology/technologies
11. The educators understood the benefits of using mobile technologies to support learning activities
12. There was a lack of operative support from the partner where the activities took place
13. If you want to elaborate on the issues regarding learners/educators/partner organizations in the project please add your comments here
14. The project team had sufficient knowledge in order to reach the goals of the project
15. Division of responsibility between the different team members was clear
16. Feel free to add any specific advice you may want to share with other project leaders concerning team management
17. The objectives of the project changed as the project progressed
18. If applicable, please share where the results of the project have been published (e.g., title, name of conferences, name of journals, technical reports, etc.)
19. The settings where the different project activities took place were much more complex than originally expected
20. It was difficult to assess the learning outcomes
21. The original project idea was initiated by an external party
22. What was the focus of the evaluation (e.g., usability, educational effectiveness, overall impact, etc.)


23. Who conducted the evaluation (e.g., outside expert, in-house expert, team effort, etc.)

24. Ethical considerations were addressed explicitly (e.g., consent, storing of data, etc.)

25. If applicable, which aspects hindered the running of the project (e.g., access to educators, limited budget, limited time, technical issues, unstable setting, etc.)

B. List of Publications


#8 Jä\textit{r}velä, S. et al. (2007), How People Collaborate to Learn in Different Context Scaffolded by the Mobile Tools, \textit{Beyond Mobile Learning Workshop}.


#14 Leinonen, T. et al. (2006), Audio Wiki for Mobile Communities: Information System for the Rest of Us, *Workshop on speech in mobile and pervasive environments, at Mobile HCI 06 Conference*.


#26 Wishart, J. et al. (2005), Using Personal Digital Assistants (PDAs) with Internet Access to Support Initial Teacher Training in the UK, *Proceedings of the 4th International Conference on Mobile Learning*.


Publication III

Addressing Sustainability for Research Initiatives in Mobile Learning through Scalability

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Abstract

Understanding research initiatives in the field of mobile learning involves dealing with complexity. It is important to gather knowledge on how to nurse these attempts. To develop ideas and reach wide deployment of novel mobile learning is of great value. In this paper there is a discussion of the factors that describe attributes of mobile learning research initiatives and an investigation of whether these are sustainable or not, and what this means. Sustainability for mobile learning initiatives is essential for the wide acceptance from both public and academia. The paper also addresses scalability of mobile learning research initiatives. Scalability is a term used to describe how well something can grow to suit an increasing complexity, and is addressed as a possibility to reflect on good ideas. Scalability is important in order to reach sustainability. Finally, this paper introduces a model that illustrates the evolutionary life cycle of a mobile learning research initiative. The model presents four evolution stages and these are: Idea, Experiment, Project, and Release.

Keywords: evolutionary life cycle model, mobile learning, reflection, research initiatives, scalability, sustainability

9.1 Introduction

Mobile learning has grown from a minor research interest to a set of significant activities in schools, workplaces, museums, cities and rural areas around the world as explicitly addressed by Sharples et al. (2008). The phrase mobile learning is used according to Naismith et al. (2004), who define it as mobile technology that supports learning across locations, or in reverse wording, that takes advantage of learning opportunities offered by portable technologies. Only a few research attempts that introduced mobile learning are ever deployed as learning aids that are in wide use (Keegan, 2005). This can be seen as a lack of sustainability (Zuga et al., 2006). The problem of sustainability when new mobile learning is introduced can in many cases be traced to bad assumptions regarding the entire situation and it can also be a hostile or at least an unwilling environment. These factors can make an attempt to introduce mobile learning unfeasible and hence unsustainable, since the research initiative did not comprehend well enough the setting that it is part of.

A typical mobile learning research initiative often starts as a technology oriented activity according to Ting (2005). This is understandable, since technology often is a limiting factor in what is perceived as possible. But moving the focus from technology to users will open up a completely new world with many more factors to consider. This process will continue as the focus is extended to cover the entire situation. Laitinen et al. (2000) refer to this process as “scaling the situation”. The notion of scaling the
situation is modeled as the change from one evolutionary stage to another in the evolutionary life cycle presented in this paper. In comparison, Boehm (1988) describes an evolutionary development process for software. A mobile learning research initiative that can complete this change successfully is considered scalable from one evolutionary stage to the other. If it proves scalable to the final stage of the evolutionary life cycle it is considered sustainable.

The evolutionary life cycle combined with the notions of scalability and sustainability provides a thinking tool for practitioners and researchers in the field of mobile learning and e-learning in general, and helps to reason about how the complexity of the system they are developing changes with evolution. The goal of this thinking aid is to increase the number of mobile learning research attempts that turn into learning aids that are in wide use and in turn increase quality, by providing a model that can be used to reflect upon and discuss the scaling process of the initiative. This paper introduces a model of an evolutionary life cycle describing the stages a mobile learning research initiative goes through. Evolutionary development methodologies (Boehm, 1988) have been suggested for e-learning, for example by Hadjerroduit (2006). Wingkvist (2008) analyzed a Podcast initiative (Bell et al., 2007) and showed how this mobile learning research initiative followed an evolutionary life cycle. This paper further introduces and illustrates the concept of scalability of a mobile learning research initiative.

The rest of this paper is organized as follows: Background to problem area is discussed in Section 9.2. Section 9.3 presents a model of an evolutionary life cycle for mobile learning research initiatives and Section 9.4 introduces scalability. Section 9.5 describes how scalability and sustainability are linked and in Section 9.6 the related results and research are presented. Finally, Section 9.7 concludes the paper and presents future directions.

9.2 Background

The interest in mobile learning has increased tremendously during the last decade. Taylor et al. (2006) acknowledge the rapid growth in research endeavors, aiming to develop and deploy mobile technologies to support learning. The information technologies finally have reached a level of maturity and ability where it is possible to support these learning activities. The emergent technologies include multimedia-equipped mobile phones, personal digital assistants (PDAs), and pen tablet computers. In line with this progress, the phrase lifelong learning is prevalent. The emphasis on supporting the learner, in collaboration with peers and lectures, both within and outside the classroom, is evident. (Naismith et al., 2004) state that the challenge will be to discover how to use mobile technologies to transform learning into everyday life seamlessly. Traxler and Kukulska-Hulme (2005) reflect critically upon the quality of mobile learning research initiatives and conclude that, to date, few studies have been grounded in sound theory.
In order to do this, a more reflective stance is needed. There is also a need to consider mobile learning not only as technology driven but also as a socio-technical system that recognize the interaction between technology and people. However, when you move from a focus on the technology and introduce users, you open up a completely new world with many more factors to consider. For example, the key stakeholders to a mobile learning implementation are: the learners, the lecturing staff, the system designers and the technical staff who implement it, and also device vendors, along with the university administration that oversees the whole mobile learning research initiative (Barker et al., 2005). The complexity is daunting and to gather knowledge on how to nurse these attempts are of great importance.

### 9.3 An Evolutionary Life Cycle Model for a Mobile Learning Research Initiative

The evolution happens in four stages: Idea, Experiment, Project, and Release. Depending on the outcome and scope, the evolution can be limited to fewer stages, but the aim of a mobile learning research initiative should always be a release in a “production” environment. Figure 9.1 describes this evolution. The model of evolution says nothing about how long each stage should take or how to move from one stage to the other. As by default, any mobile learning research initiative must evolve through the stages described. If one or more are skipped, the changes it goes through will be too large to handle. Every mobile learning research initiative starts with an idea. The Idea generally is a vague notion of what, who, and how, i.e., how should some kind of learning be transformed to a mobile device and who is the intended audience. The next step is to try out the idea in an experimental setting. In order to evolve from the Idea to an Experiment, a deeper understanding of the problem area is needed. In order to gain this understanding, the Idea stage needs to be studied closely, and these findings then is combined with an understanding of the intended target of the experiment. For example, if there is an idea to teach math using games on mobile phones, the Idea stage would mean understanding how to use
mobile phones to implement games and how to translate the mathematical content to games. In order to move on to the Experiment stage, the focus needs to be changed to which type of games actually would work, for instance by looking closer at the learners, and then to implement these. The major role of the Experiment stage is to determine if the idea works or not in a controlled setting. Hence, the Experiment stage is carried out with a small group and with much focus on figuring out what works and what does not. Once this point is reached, where there is a convincing idea and it works in practice, the next step is to move on to the Project stage. This is done by taking what was learned, study how the environment will change in the project, and combine them. The Project stage basically is a more formalized and realistic extension of the Experiment stage. A project is defined formally with stated prerequisites and a goal. There still is an interest in understanding if the idea works or not, but now the move has been made to a setting that is much closer to the intended setting. It also is important to scale the number of participants and focus closer on how they interact within the project. If continuing with the math education example, a project would implement the game on mobile phones and distribute it to a sample of the intended population. It will remain at the Project stage until it achieves stability and all the needed learning has taken place.

Further, this learning is combined with an understanding of the environment in which the end product is intended to be released. The Release stage occurs when the project ends and the novel learning aid is released as a product. In the first two stages, the focus is on getting the technology to work and dealing with the learning task or activity. Once these two are on acceptable levels, the later stages focus on introducing producers and consumers of the learning activity, as well as the organizations that for example, benefit and support the initiative. Consider the following example, focusing on the technical aspects, in continuing in which students want to learn mathematics by playing a game on their mobile phones. During the Idea stage, a mockup was created, a pen and paper model of the game, to refine the idea. When moving to the Experiment stage, a working prototype of the game is needed, but there are few requirements on the software and hardware other than that it should illustrate the concepts. It could, for example, be run on a laptop rather than on a mobile phone. Once entering the Project stage, people outside of the formal members of the project team will be exposed to the game, so it now must run on some realistic device that still can be controlled by the project, for example a particular mobile phone. Moreover, the software now must be robust enough for the users to be able to use it without problems. Another issue that may come up in this stage is the need to customize the game, i.e., to add new content or new math “problems”. In terms of software projects, the game has evolved into a project with far more formal requirements, both on functionality and quality, compared to the prototype from the experiment. If it evolves to the last stage, the software must run on the devices of the intended audience, i.e., any mobile phone that fulfills certain requirements. In a similar manner, it
is no longer possible even to interact with all the users, which for example means that the resources to deploy the software on the mobile phones, etc, must be found. The quality of the software must be even higher, and the math-game now has evolved from an Idea, to an Experiment, to a Project, and a Release with requirements similar to that of a commercial product.

9.4 The Property of Scalability

The term scalability has its origin in computer science and Bondi (2000) states that scalability is a desirable feature for a network, a system, or a process. The concept reflects the ability of a system to accommodate an increasing number of factors. A system that is not scalable cannot cope with an increase in the factors that must be handled. At the same time, the concept of scalability and the understanding of the factors that improve or diminish it are vague and even subjective. While many system designers have an intuitive feeling for scalability, the determining factors are not always obvious. This is transparent in reference to Davenport (2008), who concludes that an information system cannot be analyzed independent of the social and organizational arrangements that form its situation. Also, Hirschheim (1985) regards information systems as social rather than technical. Following in this line of thought, mobile learning systems should not be treated as technical systems with social consequences but rather as social systems with a high degree of reliance on mobile technology.

A mobile learning research initiative often starts with an idea about how to use mobile technology for a specific teaching goal. This idea can be formulated rather vaguely, for example “teach basic algebra using a mobile phone game”. The idea decides a technological platform, an intended audience and an intended setting. Each of these is, when fully explored, quite complex and interdependent. The development of a new mobile learning aid, however, does not fully explore each of these complex issues at once. They are all explored gradually during the development, as the idea is verified using one or more prototypes during one or more trials. During each of these, the system is either refined or extended to better deal with complex issues gradually as the scope is extended. For example, the game to teach basic algebra might at first be implemented on a traditional PC to overcome the problems that development for various mobile platforms may entail. Nonetheless, the PC prototype is still useful to investigate a number of properties regarding the game and the teaching.

The process of gradually extending the scope is referred to as scaling. The ability of the system to do this scaling is referred to as the scalability of the system. This scalability is not an absolute property in the sense that a system is either totally scalable or not scalable at all, nor is it desired to be. The scalability of a system indicates how well it scales to suit certain needs. For example, a game that teaches basic algebra might be scalable to suit the entire population of 5th graders in a country, or a Podcast initiative can
be scalable enough to support the needs of a number of different disciplines, each with different teaching methods, for example introductory Japanese and basic Computer Science. In the case of the development of a novel mobile learning aid, scalability is not one-dimensional but rather multi-dimensional. For example, in the case of the algebra game on the mobile phone, increasing the number of users will need additional mobile phones. But that is not the only effect of increasing the number of users as an infrastructure for distribution and updates needs to be added, i.e., technical solutions, as well as a support infrastructure, e.g., equipment, facilities, and training. In a related way, if the game scales only within a single organization, for example a school, there might not be a need to support the easy addition of new math problems or customizations of the game, but with an increased number of users, this may be a required feature. This illustrates that scaling the system will require change in multiple dimensions, and that these changes propagate throughout the system and its environment. Figure 9.2 shows this ripple effect.

In order to achieve sustainability, it is important to understand the changes that happen from scaling the mobile learning research initiative, i.e., expanding the scope.

### 9.5 Achieving Sustainability

The term scalability reflects the ability of a system to accommodate an increasing number of factors and by analyzing and understanding, which these factors are, and how they influence the development, sustainability can be achieved. As discussed in these concerns can in turn become new concerns when the system is scaled further. In order to achieve sustainability, this process needs to be understood. In regard to the game to teach algebra, assume it is running on a single mobile phone, supporting a single student. Further assume everything is working perfectly. In order to scale this to cover a class of students there are several questions that needs to be answered in order to support this scaling. For example, will the game run on existing mobile phones, or will the school supply devices to the class. To run on existing devices will put more requirements on the game and its development while using devices supplied by the school might limit the acceptance of the game. These decisions will in turn affect the cost and
how money is spent (development vs. hardware purchases). The example highlights two aspects of scalability. First, it is important that the system that is to be scaled works according to some specification. If it does not, it is hard to predict how scalability will affect the system. Second, it is important to consider the impact of scalability before decisions are made and carried out, since once the effects are noticed it may be hard or near impossible to revert the change.

Consider “MyArtSpace” (Sharples et al., 2008), a mobile learning research initiative that aimed to bridge the preparation phase as well as the follow-up work done in the classroom in connection with a museum visit. It encouraged students to produce their own interpretations of a museum visit through pictures, voice recordings, and digital notes they could share with each other and the teacher/s. The initiative was a success on both technical and educational levels but turned out to be unsustainable since scalability was not fully investigated. In the end, the museum staff could not support the technical equipment and the cost of the data traffic was not considered. In order to take scalability into account, two things need to be considered. First, it is important to keep the goal in mind and limit the scalability to only work towards the goal and use pre-set specification, as depicted by the sector in Figure 9.3.

Second, scalability should be considered as transitioning from one stable state to another. In this paper, a stable system refers to a system that works according to pre-set specification within its intended environment. When a system is stable, consider the next stage, how the system would scale to reach that stage and all the effects that happen due to the scaling. Take these into account, and scale the system. Repeat this process until the system has the required scope and functionality. In essence, a stable system with the required scope and functionality is a sustainable system.

9.6 Related Work

Bondi (2000) says that scalability is the ability of a system to change to accommodate an increasing number of factors, for example a higher demand in terms of more users. The term scalability has its origin from computer science, and is considered a quality of, for example, a network, a system,
or a process. If a system is not scalable, it cannot handle an increase of factors. The understanding of scalability often is vague and subjective, but a number of research efforts to define this notion have been carried out. Laitinen et al. (2000), in addition to Weinstock and Goodenough (2006) give a good overview of the underlying concepts and problems of scalability in relation to system development. Stone (2004) investigates the notion of scalability in relation to mobile learning, with reference to content delivery, i.e., how can a teaching material be adapted automatically to fit a number of possible platforms, both e-learning wise and mobile? For example, can a video stream be reduced to pictures, and will the learning remain when this scaling happens? In fact, Stone wants digital content to be able to be reused across different technologies and network solutions, still ensuring the pedagogic “value” of the material. Stone also wants to highlight the issue of scaling up relatively small pilot projects, using the results gained as input to new research initiatives in order to reach wider deployment. The term sustainability is defined by Eckersley (1998) as the ability to continue an activity or maintain a certain condition indefinitely. Black (2004), in connotation to communities and societies, says that sustainability increasingly is seen as involving three interrelated dimensions: the economic, the social, and the ecological. These dimensions all need to be considered when thinking about sustainability in this context. When applied to systems in a general sense it relies on Beer (1984), who states that a viable system needs to be organized in a way to meet the demands of an ever-changing environment in order to survive. The Darwinian saying “survival of the fittest”, from Darwin’s theory of natural selection, comes to mind, and a system needs to be able to maintain a separate existence over time. Therefore, the end product needs to be stand-alone to its creators and sustain a steady state by itself.

Traxler and Leach (2006), and McFarlane et al. (2008) address both the concepts of scalability and sustainability, in a similar way, at least intentionally, to how they are defined in this paper.

Traxler and Leach (2006) use the notions of scalability and sustainability in a study of two mobile learning research initiatives in Africa. These are called the “DEEP” project, which takes place in Egypt and Eastern Cape Province of South Africa, and the “SEMA” project in Kenya. Both projects are investigating the impact of portable technologies on teachers’ pedagogy and practice. The two projects used different approaches in establishing the communication platform. The “DEEP” project invested more resources on the technical solution with PDAs and laptops while the “SEMA” project utilized available technology (mobile phones) and standard for communication, i.e., GSM. The projects differed considerably in the number of users, with the “DEEP” project involving 50 teachers while the “SEMA” project addressed almost 100,000 teachers. Traxler and Leach find that both scalability and sustainability prove to be two key challenges, due to infrastructure, technology, equality, and policy.

McFarlane et al. (2008) bring the concepts of scalability and sustainability
to be addressed in relation to main policy issues. McFarlane et al. provide the following points to be of relevance: support and funding, devices (specification, supply, services, and commercial interests), local authorities and school, technical issues, and professional development of teachers, in this respect. Further, McFarlane et al. stress that all are necessary to comprehend when scaling up the use of mobile technology in an educational setting. They suggest that the main funding agencies should adopt a new model that includes these points before giving out funds.

This model should thus focus on these issues and promote (re-) using successful results from pilot projects, and teacher knowledge exchange, as an input for new projects and potentially reach wider deployment, and hence sustainability. This will in turn follow with more acknowledgment from the public and also give the field of mobile learning the success stories it so desperately needs to be accepted in the world of academia.

\section*{9.7 Conclusion}

This paper discusses a model for an evolutionary life cycle to illustrate how mobile learning research initiatives are carried out. In order to help reason about the changes occurring when transitioning from one stage to another during this development, the notions of scaling the system and scalability are introduced. Scaling the system refers to how the initiative grows from one stage to another. Scalability describes how well a system change in relation to increasing demands put on it. This is different when dealing with a mobile learning research initiative compared to developing software since mobile learning is to be viewed from a socio-technical point and the actual change may be in the interaction between people (within the initiative) rather than the corresponding software. A mobile learning research initiative that is scalable to the final stage of the evolutionary life cycle, namely the release stage, is considered sustainable.

The aim of this paper is to help increase the reflection upon, and the understanding of the evolution and change during the development of mobile learning research initiatives. By providing a model that illustrates scalability in stages, the quality of the development process could be increased. The evolutionary life cycle model and the notion of scalability as presented in this paper is not the only way for mobile learning to achieve sustainability. There exist several other frameworks and models to aid the development. However, many models and frameworks are not focused on evolutionary development, something that seems very natural to e-learning and mobile learning. Also, in some cases where evolutionary development is the focus, the process is not adapted for socio-technical systems, again something that is very natural to learning. The model presented in this paper provides an intuitive entry to reason about scalability and change in socio-technical systems that follow an evolutionary development.

An important future task is to see if the notion of scalability and the use
of it combined with the evolutionary life cycle are intuitive enough to be used during the development of future mobile learning research initiatives. A first task would be to determine the usefulness to the development team. If proven useful, a second task would be to see if the life cycle increases reflection and in turn how that reflection would change the end product. Only then can the quality of the product and in turn the usefulness of the model be evaluated. Other future work is to figure out whether the model can be used to guide evaluation. The evolutionary life cycle (model) hopefully could be used to pinpoint moments in time when evaluation should take places for best results in regard to the development process. Also, the scaling before the evaluation stage could guide to what should be evaluated next.

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Publication IV
Publication IV

Bringing a Framework to Tackle the Development Process in Mobile Learning

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Abstract

This paper presents a study that was conducted of the development process of an initiative that used podcasts (i.e., digital audio-files) to supplement lectures in higher education. A thorough data gathering was conducted using the iterative cycles of the action research approach. The empirical data was analyzed and this analysis resulted in a framework that shows how sustainability and scalability are linked. The framework also shows how an initiative is developed from Idea, to Trial, to Project, to Release, and how each of these stages can be described using four areas of concern, namely, Technology, Learning, Social, and Organization. Using the experience from a specific mobile learning initiative to define a framework that is then used to conceptualize the development process is a way to bring together practice, theory, and research, and thus provide reliable evidence for the framework itself. The framework captures the development process and the relevant context in a unified theoretical attempt and is suitable for practitioners dealing with initiatives in the field of mobile learning.

Keywords: action research, conceptual modeling, framework, mobile learning, scalability, sustainability

10.1 Introduction

The research presented in this paper studies the development process of a mobile learning initiative involving podcasts (i.e., digital audio-files that can be listen to “on the go”) in order to better understand the evolution of it. The development process is then abstracted into a theoretical framework, consisting of text, figures, and the use of references to support the key concepts it is built upon. This theoretical framework can be used by practitioners involved in mobile learning to reason about the development process. In this way some of the complexity involved in development of mobile learning initiatives can be reduced, at least conceptually speaking and aid in the set-up phase of new efforts in this field.

Thus, in the process of seeking what can be of a practical orientation, the aim of this research is to provide new theoretical contributions (e.g., a framework) based on the local knowledge gained from actively participating in a mobile learning initiative to aid other practitioners entering in a similar situation.

The rest of this paper is structured as follows, next is Section 10.2 that addresses the theoretical fundamentals, which this research is based upon, continued by an introduction to the problem area in Section 10.3. The research approach is described in Section 10.4, followed by a description of the empirical setting in Section 10.5. In Section 10.6 the framework is brought
forward and further discussed in Section 10.7. Conclusion and future work are presented in Section 10.8, followed by limitations in Section 10.9.

10.2 Theoretical Foundation

In this research, the aim are on understanding and interpreting the development process that actually took place, hence the research is done to understand the situation and the process of implementation, use, and impact of a real information system. From an Information Systems perspective the process of understanding the situation at hand and conduct the development process in itself is either done by incremental delivery or spiral development (Sommerville, 2006). According to Royce (1970) the original waterfall model consists of the following steps: system requirements, software requirements, analysis, program design, coding, testing, and operations. The steps are in a sequence, one step has to be finished before the next one is started. The spiral model was first described by Boehm (1988). The spiral model is an enhancement of the waterfall model, using an incremental strategy instead of a strict sequential. The main stages are the same, although some steps are iterated and for every iteration, the part of the information system that is produced, is refined. The waterfall model and the spiral model are generic models, and often used in combination or variants of each other as stated by Sommerville (2006).

One example of this presented by Kruchten (2000) is RUP, the Rational Unified Process, which is based on UML, the Unified Modeling Language and have four phases. The first one is the inception, establishing a business case and identifying people and systems interacting with the information system. The second is the elaboration phase, which has the goal to develop an understanding of the problem domain, to establish an architectural framework for the system, develop the project plan and identify key project risks. The third phase is the construction phase, dealing with system design, programming, and testing. The fourth and last is the transition phase, which is concerned with moving the system from the development community to the “real” community and making it work in that environment.

This development process is fundamental knowledge within Information Systems studies and provide the cornerstone of the theoretical foundation this research started with, concerning the development process in regard to develop, implement, use, and understanding the impact of an information system in the field of mobile learning. Mobile learning as a research field is emerging, having a rapid growth in development initiatives aimed to take advantage of learning opportunities offered by portable technologies (Naismith et al., 2004).

Naismith et al. (2004) continues with stating that the real challenge will be how to seamlessly integrate (develop, implement, and use) portable technologies in learning situations and sustain their existence in the intended setting. This research is derived from actively participating in one such
10.3 Reaching Sustainability Through Understanding Scalability

As mentioned in the previous section, learning supported by mobile devices need to handle a magnitude of issues due to the inherently complicated situations, initiatives in mobile learning are exposed to. Mobile learning has evolved from just a technical tool, aimed to make learning more fun, to something meant to be a more integrated part of the setting it is brought into according to Sharples (2000). Few mobile learning initiatives are ever developed into learning aids (i.e., information systems) that are in wide use (Keegan, 2005). The problem of initiatives seldom leading to wider deployment or even further acceptance can be seen as a lack of sustainability, as mentioned by (Zuga et al., 2006). The problems these initiatives face can be traced to somewhat vague if not even wrong assumptions in respect to comprehending the overall situation, i.e., when dealing with techniques, pedagogics, and people. The number of issues and what follows in terms of factors to consider clearly is huge and not easy to grasp to full extent.

Hence, in order to increase sustainability, the need to increase understanding follows. To explain further, when looking at a typical mobile learning initiative, many of these often start as technology oriented activities, as discussed by Ting (2005). This is reasonable, since technology often is a limiting factor in what is perceived as possible. However, when you move from a focus on the technology to learning activities and introduce stakeholders and their requirements for what the initiative and the information system to follow really should support, you open up a completely new world with many more factors to consider. This process will continue as you extend your focus to get the relevant picture. Laitinen et al. (2000) refer to this process as scaling the situation.

In order to understand better the situation and the issues that may have an impact on sustainability, there is profound need to acknowledge all the requirements placed on such an initiative — to see the overall setting and identify the relevant parts — scalability in its essence. The terms of sustainability and scalability are further developed throughout the paper, together with how a framework is brought forward to describe and explain the development process of an actual mobile learning initiative. In implementing
mobile learning, the people that are involved, the practitioners, are exposed to an inherently complex situation, which affects the sustainability of these initiatives. The word practitioner is used in accordance to the Oxford Dictionary, which defines it as “a person who is actively engaged” (McKean, 2005). The first author of this paper can be seen as a practitioner, who utilized the approach of action research to gain understanding of a mobile learning initiative and establish facts and conclusions on a real world phenomenon. This is done in order to help other practitioners placed in the same position of initiating a mobile learning initiative, providing them with a better understanding of what they are faced with.

10.4 The Action in Action Research

Given the research question, the answer can be sought by utilizing an action research approach since an action research approach is designed to bridge the gap of theory, research, and practice according to Holter and Schwartz-Barcott (1993). One characteristic of action research, specified by Hult and Lennung (1980), is that the approach is applicable primarily to understand change processes in the real world. Action research often is depicted as a cyclic process and involves four linked phases (Kemmis and Wilkinson, 1998). These consist of planning, action, observation, and reflection. Thus, the theoretical contribution emerges through iterations of action research cycles (Baskerville, 1999). The first author of this paper was new to the fieldwork connected to a mobile learning initiative per se, but entered the field with a theoretical, as well as a research, background. One major consequence of the choice of an action research approach is that the research is context-bound as opposed to context-free (Horsburgh, 2003).

It is difficult to determine the cause of a particular effect, which could be due to environment (including its subjects), researcher, or methodology. Even though the results of action research are qualitative in nature and attached uniquely to the research, they do offer a degree of external validity, according to Avison et al. (2008), since the theoretical contribution developed can be interpreted and refined by others in other real world situations. Furthermore, Avison et al. (1999) say that action research can address complex real-life problems and of immediate concerns of people in the field, although the findings as well as their presentation, need to be in accordance with the audience and often of a descriptive character, as recognized by Small (1995).

The iterative cycle of planning, acting, observing, and reflecting supports an analysis of an application area and has been utilized for the research. Figure 10.1 illustrates this cycle (Riding et al., 1995). The aim was to contribute to the practical concerns of people in a problem-riddled situation and to develop an understanding that possibly could help increase the competence and self-help ability of practitioners in the field of mobile learning. In identifying findings and specifying the learning, a framework was devel-
The research process of extracting the theoretical framework from the empirical data is what is targeted in this paper.

In order to analyze the application area, the iterative cycle of the action research approach was utilized in three iterations. The first two iterations established the foundation for the continuing use of podcasts to supplement lectures in higher education. The first iteration studied the construction and results of surveys (cf. Bell et al. (2007)) and data logs, as well as observing the initial reactions.

From the student body and it was followed by discussions with the initiator of the initiative. After the first iteration, the initiative grew both in size (i.e., number of stakeholders, students, lecturers, and the university administration) and complexity (i.e., more factors to be made explicit). The lessons learned from the first iteration as well as the change in the initiative led to the formalization of themes and the need to understand the demographic characteristics better. The themes were: Technical/Environmental issues, Podcast content, Pedagogical issues, and Overall impressions. The demographic characteristics were: Age, Discipline, Gender, and English language proficiency. This initiated the second iteration, where the issue of scalability became apparent (cf. Wingkvist and Alexander (2007)).

After returning to the Center for Learning and Knowledge Technologies (CeLeKT), a research group at Växjö University, Växjö, Sweden, the first author of this paper studied other mobile learning initiatives and noticed that few results reach a wider audience, particularly in terms of deployment. The third iteration started with this discovery and introduced the concept of sustainability, in an effort to systematize the perspectives of the field of mobile learning (cf. Wingkvist and Kurti (2008)).

In following the approach of action research, reflecting on the process of the podcast initiative was part of the iterative cycle, and four distinct development stages could be identified. Within each of these stages, four areas of concern could be identified, as well. These were identified by analyzing and classifying the questions of the surveys, supporting the scientific contribution and validating the findings. The result of the third iteration cycle...
was the construction of a framework and is a product of interpretation, and should be regarded as indicative rather than conclusive.

The experience gained during this research enabled the opportunity to contribute to the theoretical enhancement and define a framework that attempts to illustrate the scaling process leading to a sustainable information system in the field of mobile learning. The aim is for the framework to be useful as a thinking aid for practitioners involved in initiatives concerning mobile learning and provide a mean to understand the situation and handle the development process accordingly. Next section address the empirical case, the Podcast initiative, to give an introduction of the actual setting and practice.

10.5 The Development Process of the Podcast Initiative

The podcast initiative started with an idea. The initiator, Tim Bell (professor in Computer Science at Canterbury University, Christchurch, New Zealand), listened to podcasts while doing other activities, such as riding his bike to and from the university. He imagined that students had similar activities in their lives and that they would benefit from and appreciate the ability to refresh course work while doing these often mundane activities (such as commuting and household chores). A number of concerns grew from the idea that potentially could affect how well the students accepted the podcasts as a learning aid. For example, was the technology required, both to download and listen to podcasts, (such as digital audio players) in use by the student body? Another concern was whether the students were willing to, or already did, download and listen to (other) podcasts. A final concern was the content of the podcasts, for example if complete lectures should be recorded, or if material should be tailored for the podcast format, and if so, what kind of material was suitable.

The technology needed to listen to and produce podcasts is not that advanced. A podcast is a digital audio file that can be played on a number of devices, such as portable digital audio players, mobile phones and computers. The idea was not so much to investigate the technical issues, but rather to determine if the technology already was being used in the target group. In order to investigate this, the students were asked to answer a few questions regarding their use of podcasts and digital audio. They also were asked if they would listen to educational podcasts and, if so, which format they would prefer (i.e., 1-to-1 sound uptake from lectures, supplementary material, or additional material). The questionnaire was analyzed and used as a means to gain understanding of the situation. This understanding provided enough information to support a larger study. The initiative was extended to cover two Computer Science courses, being around 400 students in all. The podcasts were produced as a supplement to the traditional teaching, so it would not affect the students who for some reason did not want to or
10.5 The Development Process of the Podcast Initiative

could not adopt the technology.

The primary goal was to investigate how the different types of podcasts would work in practice and what the students would prefer. Also, by combining learning with such activities, it is necessary to be aware of distractions, the inability to take notes or look up references, etc. Therefore, a suggestion was made to provide material to supplement the lectures. So, within the initiative supplementary podcasts were offered to two first-year Computer Science courses. The two courses offered weekly podcasts. One of the courses used 20 minute long podcasts with one presenter, while the podcasts for the other course varied in length (20–60 min) and used two presenters. Both used a similar format; the past week’s material was reviewed, there were discussions, commentary, interviews with others, future topics in Computer Science were addressed, and the students were reminded about upcoming events and deadlines.

Another important goal was to improve the technical solutions and make the production efficient. In order to test what the students preferred in terms of material, several different types of podcasts were prepared, ranging from supplementary interviews and Q&A (questions-and-answers) sessions, to 1-to-1 sound recorded lectures and even reading from a textbook. These activities all fit with the educational goal. In order to continue to explore the state and the potential, a second questionnaire was used to evaluate what the students experienced.

This questionnaire repeated a few questions from the first questionnaire, such as if the students would use the podcasts or not. In measuring what format (lecture versus supplement) the students preferred and how the technical solutions worked out, the questionnaire was used in conjunction with other collected data, such as download records and observation of the student body.

Several interesting refinements can be noted on the technical side, caused by the progress from an idea to a small scaled trial. For example, there was a server crash, which made the podcasts inaccessible for some time. This might have had an effect on the number of students who tried the podcasts, since those who did so during the server problem might have been reluctant to adopt the technology. Similarly, it was discovered that there was a need for a subscription model, since many students forgot to download and listen to podcasts when they had to do it manually. Based on the results of the analysis of the second questionnaire, five weeks later, it was decided to extend the study again, this time to include more disciplines and in turn more courses, lecturers, and students. The results also were used to gain funding from the university for this part of the study. Until now, the study had been conducted on a voluntary basis.

After the first semester, the number of disciplines that used podcasts expanded by including courses from Economics, Japanese, Music, and Pedagogic. The initiative also did receive funding from the university at this point and was called a project by the involved people. The format of the podcasts was similar to the previous step, i.e., both lecture (1-to-1 sound
### Table 10.1: An Overview of the Stages of the Podcast Initiative.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Purpose</th>
<th>Outcome</th>
<th>Key Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idea</td>
<td>Establish soundness of the idea</td>
<td>Plan of how to go ahead</td>
<td>Investigate technology, Investigate feasibility, Surveys</td>
</tr>
<tr>
<td></td>
<td>Establish technical platform</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trial</td>
<td>Test the idea</td>
<td>Information about what works and what does not</td>
<td>Produce podcasts, Offer podcasts, Measure how well they are received</td>
</tr>
<tr>
<td></td>
<td>Elaborate the learning</td>
<td>Considerations made on what needs to change in order to move ahead</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Small scale testing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project</td>
<td>Expand beyond initiators</td>
<td>Information on how the podcasts are received, both in terms of students and teachers experience</td>
<td>Similar to trial but larger scale, Report to funding organization</td>
</tr>
<tr>
<td></td>
<td>Large scale testing</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Formalized in terms of resources and outcome</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Establish social interplay</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Release</td>
<td>Hand over to target organization</td>
<td>Implemented and in use</td>
<td>Integrate into the organization (training), Establish facilities (servers, studios, etc.)</td>
</tr>
<tr>
<td></td>
<td>Remove reliance on initiators</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

uptake) and supplementary podcasts. The use of podcasts was evaluated throughout the initiative, primarily by questionnaires.

A new and important goal was to investigate the implications of how different people in different roles are willing to use and accept the technology. Interesting questions to research were how students learn, i.e., if they prefer audio or if they need visual aids, the environmental effects (e.g., distraction, disturbance), and the willingness and ability of other lecturers to produce podcasts. Another change was that the university now had a stake in the study. For example, by receiving funding there was now an obligation to report findings, which might affect already defined structures concerning the setup and the educational goal. In a similar manner, there was a need for a larger infrastructure to help lecturers produce podcasts, for example training, access to a studio, equipment, etc. There also was a need for a better infrastructure so students could access the podcasts. Furthermore, there are Internet traffic fees in New Zealand at the university, connected to the student login accounts, and these fees might affect the willingness of students to download podcasts. A questionnaire was created to evaluate the potential and to see if the podcast initiative could be applied to the whole university. As a consequence of being a visiting researcher, the first author of this paper left before this evaluation was done. So, no comment can be made on the further impact of the Podcast initiative. Instead, an abstraction of the development process from a practitioners standpoint was brought forth in form of an accessible framework, providing a theoretical contribution in the field of mobile learning.

The development of the podcast initiative is summarized in terms of stages, purposes, outcomes and key activities in Table 10.1.
As mentioned previously, the framework is based foremost on the experiences with a mobile learning initiative whereby traditional university education, i.e., lectures, was extended and made mobile with the use of podcasts. The implications of being a visiting researcher resulted in extensive insight of how the mobile learning initiative developed, but not always why. To gain this knowledge and investigate the why, factors that could be identified were sought. As the framework started to take form during the work with the mobile learning initiative involving podcasts, and as the research continued, the answer to both how and why were found. Finding the relevant results was an outcome from utilizing the process of iterative cycles of the action research approach. These results then were put together in the shape of a framework handling the development process, interlinking text and figures to correspond to the intended audience of practitioners involved in the process of initiating a mobile learning initiative. Further the key terms: scalability and sustainability is further developed as intricate parts of the framework suggested.

Hence, the development of the Podcast initiative was analyzed and four main stages can be discovered, cf. Figure 10.2. First, there was an idea. After testing whether the idea would work or not, it was extended to a trial. During the trial, the findings of the idea were verified using courses that were running and in turn the students enrolled, together constituting a relatively highly controlled environment. For the third stage of the study, a project was started, and funding was introduced, i.e., formalization of the environment (e.g., disciplines, lecturers, students, technical solutions). The goal was that the third stage would be the final test of the study, and the underlying ambition was that podcasts would be released as an educational aid across the whole university as a result. This would be the fourth stage. The framework illustrates the development of a mobile learning initiative, which includes the stages from Idea, Trial, Project, and Release.

The stages introduced can be considered steps in the development of a mobile learning initiative, and every initiative starts with an idea. The Idea
generally is a vague notion of what, who, and how, i.e., how should some kind of learning be transformed to a mobile device and who is the intended audience. The next step is to try out the idea in a setting where high degree of control can be gained. With other words, the idea is morphed into a trial with a more realistic setting but with a high degree of control. In order to develop from the Idea to a Trial, a deeper understanding of the problem area is needed. In order to gain this understanding, the Idea stage needs to be studied closely, and these findings then is combined with an understanding of the intended target of the trial. The major role of this stage is to determine if the idea works or not in a relatively controlled setting. Hence, the Trial stage is carried out with a small group and with much focus on figuring out what works and what does not. Once this point is reached, where there is a convincing idea that works in practice, the next step is to move on to the Project stage. One can say that the trial is transitioning into a project with an even more realistic formalized setting. This is done by taking what was learned, study how the environment will change in the project, and combine them. A project is defined formally with stated prerequisites and a goal. There still is an interest in understanding if the idea works or not, but now the move has been made to a setting that is much closer to the intended setting. It also is important to scale the number of participants and focus closer on how they interact within the project. The initiative will remain at the Project stage until it achieves stability and all the needed knowledge has been gathered. Further, this knowledge is combined with an understanding of the environment in which the initiative is intended to be released, and once reached the project would develop into deployment.

This Release stage occurs when the project ends and the mobile learning initiative is formally finished and the developed information system is released as a learning product, incorporated into the intended setting without constant assistance (i.e., technical development, targeted founding) by “external” parties. The overall goal is that the information system be handed over via natural transition of ownership and responsibility in the project stage, for comprehensive deployment in the target organization at the next stage.

Each of the identified stages is distinct and separated from the others by some kind of reflection, often in the form of an analysis of a questionnaire. For example, the idea stage ends with the analysis of a questionnaire that was posed in order to test the viability of the Podcast initiative in the intended environment.

The important development that happens throughout the process happens within the stages, and all of the stages are separated into main topics. For example, the first stage was concerned primarily with the acceptance of the technology and the learning activity. An analysis of the three questionnaires used during the development reveals four major areas of concern. These can be classified as issues regarding: the technical set up, the learning activity, the social interplay, and the organizational setting. From the
experience gathered with the Podcast initiative, a mobile learning initiative can be defined by four areas of concern: Technology, Learning, Social, and Organization. These areas, as depicted in Figure 10.3, are interconnected and of equal importance — keeping in mind what the mobile learning initiative as a whole is supposed to achieve. Each area will be the focus of concern during at least one of the stages.

The Technology area involves all the actual technology needed to realize the initiative. This includes hardware and software, for example mobile phones, servers, blogs, etc. The technology often is what is perceived as the focus, and the limiting force, of any mobile learning initiative. It is therefore important to acknowledge the technology and its relation to the entire situation. The second area of concern is the Learning. Learning is refereeing to a number of considerations that need to be meet, all aimed to guide a sound knowledge transfer. It is separated from technology since the technology is there only to facilitate the learning, not to be the center of it. In a similar manner, its focus is only on the actual translation of the learning activity to the mobile device in this area and not on the actual producers and consumers of learning. Since learning is the inherent goal of any mobile learning initiative, it is important enough to constitute its own area: how will people learn, what are the important characteristics of the learning, how can a learning concept be transformed into something suitable for the initiative, etc.?

The third area of concern is the Social. This includes the people involved in the process, and the parts they play. All learning will happen in a social situation, and even if it happens via mobile devices, there will be social interplay. In order to create a working mobile learning initiative, it is very important to understand how the people involved “work” and what they want. The fourth and final area of concern is the Organization. Any work situation is controlled by rules and regulations — this is the main function of an organization — as well as to provide support and infrastructure. Any mobile learning initiative will exist within one or more organizational settings, each complete with agendas, policies, politics, etc. In order to work with in these organizations it is vital to understand the setting well enough to be able, at least, to coexist with it.
The analysis of the development of the Podcasting initiative reveals some major concepts. The development is divided into stages and the activities of each stage addresses four areas of concern. When the initiative moves from one stage to another, it gets more complicated to deal with and it scales. In each stage, there is a focus on some areas of concern, and this focus shifts throughout the stages.

The four areas of concern are interlinked and affect each other, and focus only refers to the foreground area of concern. Changes to the focused area(s) will affect areas that are not in focus. There is a need to achieve equilibrium in a stage, with other words there is an evolutionary process within a stage where a change to one area is reflected by the other areas. Equilibrium according to the Oxford dictionary is “a state in which opposing forces or influences are balanced” (McKean, 2005), and is a step towards a sustainable mobile learning initiative. The terms scalability and sustainability are intricate key terms in the theoretical framework suggested and reaching equilibrium in a stage before moving to the next should always be the goal.

Next, in text form the reasoning behind these key terms and their relation are further developed and some of the concepts, showing the development process, are depicted by Figure 10.4. The concept of focus is shown as an arrow, which indicate how the attention in respect to areas of concern moves throughout the development process.

The term scalability has its origin from Computer Science, and is considered a quality of, for example, a network or a system. If an information system is not scalable, it cannot handle an increase of factors. The understanding of scalability often is vague or subjective, but a number of research efforts to define this notion have been carried out. Laitinen et al. (2000), in addition to Weinstock and Goodenough (2006), give a good overview of the underlying concepts and problems of scalability in system development. Bondi (2000) in relation to an information system, judge how scalable it is.
when the information system needs to accommodate to changes, for example a higher demand in terms of more users or hardware.

Scalability can be considered as the initiative’s ability to evolve. This growth, in respect to all the four areas of concern should be able to handle different types and groups of users and organizations with everything that this entails. There will always be a point at which scalability stops making sense, i.e., a largest rational organization it can scale to or a “market” that can be “controlled”. Using this description, scalability can be defined as the ability to reach a state that matches the pre-set requirements at a development stage. The more stages at which it reaches these, the more scalable the initiative is. In this respect, saying that a mobile learning initiative is scaled to Project stage simply means that the initiative reached a state in accordance to the specified variables at Idea, Trial, and Project stages. The components were in unison with each other at each stage.

The term sustainability is defined by Eckersley (1998) as the “ability to continue an activity or maintain a certain condition indefinitely”. Black (2004), in connotation to communities and societies, says that sustainability increasingly is seen as involving three interrelated dimensions: the economic, the social, and the ecological. These dimensions all need to be considered when thinking about sustainability in this context. When applied to systems in a general sense it relies on Beer (1984), who states that a viable system needs to be organized in a way to meet the demands of an ever-changing environment in order to survive. The Darwinian saying “survival of the fittest”, from his theory of natural selection, comes to mind, and a system needs to be able to maintain a separate existence over time. Therefore, the end product (i.e., the information system) of a mobile learning initiative needs to be standalone to its creators and sustain an existence by itself in the intended setting.

The term sustainability is described as something that can “be maintained at a certain rate or level” to cite the Oxford Dictionary (McKean, 2005). If considering ecological sustainability, it is defined as conserving an ecological balance. If transferring this kind of striving within the framework, a sustainable mobile learning initiative would be one that reaches the last stage, i.e., the Release stage, and is incorporated into the targeted environment. The goal is a mobile learning initiative that survives on its own merits and adapt to changes in the environment. By combining the definitions of scalability and sustainability, sustainability is the same as “maximum” scalability. The key concepts are summarized in Table 10.2.

10.7 Discussion

In the previous section a theoretical contribution in form of abstracting the development process of a mobile learning initiative was presented. Further, a reasoning of the key terms of the framework was provided. Thus, the four areas together form a relevant picture of a mobile learning initiative.
Publication IV: Bringing a Framework to Tackle the Development Process in Mobile Learning

The development of a mobile learning initiative goes through a number of Stages. Mobile learning initiatives go through an evolutionary process that can be summarized using the following four stages: Idea, Trial, Project, and Release.

### Areas of Concern
Each stage deals with a number of concerns or requirements that deal with different aspects of the mobile learning initiative. There exist an interplay of technical, pedagogical, people-related, and bureaucratically considerations and these in short are called the following areas of concern: Technology, Learning, Social, and Organization.

### Focus
Focus is a way of reducing complexity. Each stage deals with the areas of concern, but it was found that certain areas are more prominent during certain stages. By applying focus on particular areas, these provide the primary concerns to investigate.

### Equilibrium
The concept of Equilibrium is the measure of when the inner evolutionary process has reached a “final” state. When all the concerns within a stage, both those within areas in focus and those indirectly affected by the focused areas are in balance, equilibrium has been achieved.

### Scalability
Scalability indicates how well the initiative is able to grow. When an initiative reaches equilibrium at one stage and is able to refine or add to the considerations within the areas of concern that should be dealt with in the next stage, it scales from one stage to the next. Scalability is the measure of how many such scalings the initiative can accomplish.

### Sustainability
Sustainability is the measure of how well the result fits the intended setting. An initiative that has scaled a stage with realistic and “final” concerns and reached equilibrium at this stage is considered sustainable.

| Stages | The development of a mobile learning initiative goes through a number of Stages. Mobile learning initiatives go through an evolutionary process that can be summarized using the following four stages: Idea, Trial, Project, and Release. |
| Areas of Concern | Each stage deals with a number of concerns or requirements that deal with different aspects of the mobile learning initiative. There exist an interplay of technical, pedagogical, people-related, and bureaucratically considerations and these in short are called the following areas of concern: Technology, Learning, Social, and Organization. |
| Focus | Focus is a way of reducing complexity. Each stage deals with the areas of concern, but it was found that certain areas are more prominent during certain stages. By applying focus on particular areas, these provide the primary concerns to investigate. |
| Equilibrium | The concept of Equilibrium is the measure of when the inner evolutionary process has reached a “final” state. When all the concerns within a stage, both those within areas in focus and those indirectly affected by the focused areas are in balance, equilibrium has been achieved. |
| Scalability | Scalability indicates how well the initiative is able to grow. When an initiative reaches equilibrium at one stage and is able to refine or add to the considerations within the areas of concern that should be dealt with in the next stage, it scales from one stage to the next. Scalability is the measure of how many such scalings the initiative can accomplish. |
| Sustainability | Sustainability is the measure of how well the result fits the intended setting. An initiative that has scaled a stage with realistic and “final” concerns and reached equilibrium at this stage is considered sustainable. |

Table 10.2: The Key Concepts Summarized.
However, the focus can and most likely will be on one area at a time and advance in that manner. For example, during the Idea stage, there will be some vague ideas about “how”, “what”, and “who”. The most likely turn of events will be to begin with a focus on Technology and solve that area before moving on to Learning. The other areas still are present and important, but the focus is on technical problems and the counterpart of solutions.

In using the metaphor of a camera, Avison et al. (1998) made the process of mediation easier to understand. They are comparing it to changes of a picture as the camera lens zooms in and out and then how to handle the focus of attention in for example a mobile learning initiative. The focus will move from one area to another, revisit, and discover if the situation has changed. One area might be the focus of attention at a particular time, but the other areas are still present in the peripheral vision. It is possible to see all four areas at the same time, but only by sacrificing the level of resolution. By contrast, it is possible to focus in and examine one particular area in great detail, but at the expense of losing some of the greater context. Think in terms of a camera lens that zooms in on different parts of a picture, cf. Figure 10.4. The part that is zoomed in on is sharp and detailed, but the other parts are still there, even if blurry.

Even if focusing on one particular area, changes to and developments of that area may influence the other areas. As presented in this section, there is much interaction going on between the different areas, and even a subtle change to one area can affect all the others in various ways. An interesting question is how can these changes be understood and when is it enough: how do you know when it is time to stop, and in turn when to move on?

Within each stage of the initiative a stable state should be reached since it will make it possible to better reflect on what is needed in order to be enhanced for entering the next stage. Reaching that state means that the initiative is working as planned. An initiative working as planned is as important during the development as it is during the release stage. If the initiative is not in accordance with pre-set requirements, it is hard to measure and extract any meaningful data, which are needed in order to be able to develop to the next stage. For example, assume that an initiative is in the Trial stage, in which the initiative is not in line with the plan due to a poor software solution. The deficient software will reflect badly on the initiative and it will be hard to separate the poor response that was due to the software from eventual poor response to the entire initiative.

In a similar manner, development is controlled by specifications and an information system should at each stage be a complete package at least in the conceptual sense addressing the four areas of concern. If attempting to move forward, without making a proper analysis of the findings of the stage at which the initiative is currently, the possibility to adjust and use this input for the next stage is lost, ultimately not giving the initiative the best prerequisites to develop into the next stage. The concept of focus and how the focus is on one area of concern at a time are discussed. The same holds
true for development. In each stage of development, one or a few areas dominate the focus. This is due to the increasing complexity of the mobile learning initiative. A simple way to describe the areas of concern is that each area adds an additional layer of complexity, i.e., factors to consider.

The more complex the initiative gets, the more of these there are to worry about. In the first two stages, the focus is on getting the technology to work and dealing with the learning task. Once these two are on acceptable levels, the later stages focus on introducing producers and consumers of the learning activity, as well as the organizations that for example, stand for the founding. These generally are far more complex and need to be in focus once the first two areas of concern are stable enough to built upon.

10.8 Conclusions

The main contribution of this research is to bring forth a framework, which shows the evolution of a mobile learning initiative. This paper presents how empirical data gathered mainly during a podcast initiative was used to abstract a theoretical framework that models the development process as well as the relevant situated topics to address. The framework shows how development of a mobile learning initiative happens in stages, from Idea, to Trial, to Project, to Release. The activities within each of these stages addresses four areas of concern: Technology, Learning, Social, and Organization.

The areas of concern are linked and affect each other. Usually, focus on one area of concern is applied as a means to reduce the complexity of the setting. The concepts of sustainability and scalability are used in the framework to deal with different issues within the stages and the evolution of the initiative. The key to sustainability is the notion of equilibrium — to achieve a balanced and steady state — in each stage, before scaling can happen. This in turn is linked to the acceptance and survival of the mobile learning initiative. The framework uses stages to model the development process and areas of concern to model the situation.

The framework was created using the process of iterative cycles of the action research approach and provides key concepts that show the development process in a way suitable for the intended audience, practitioners involved in mobile learning initiatives. These key concepts can help the practitioners reflect upon the development process in many ways. They can for instance map activities happening within the initiative to concepts in the framework, reason about these and then translate the findings back to the activities. Another use is to arrange the setup of new initiatives according to the framework.

During the research, no models, frameworks, or reflections similar to the theoretical contribution presented in this paper were found. Even if the framework defined has yet to be proven general enough to be applied to other mobile learning initiatives, the model can prove helpful to practitioners in
the field of mobile learning and an important future challenge is to test the framework to determine whether it can be intuitively understood. This test is done to see if the perceived complexity of a mobile learning initiative can be understood better and handled accordingly. The development process is made explicit in relation to the magnitude of factors to follow, which can aid in identifying both the time (literally) and the issues concerned. To use the framework to guide evaluation would also be an interesting path to follow.

10.9 Limitations

The result of this paper is a product of interpretation, and should be seen as indicative rather than conclusive in any way. Its purpose was to give other researchers insights gained from actively participating in a mobile learning initiative and provide a theoretical contribution based on this. This is to understand better the different findings throughout the research and put them into a theoretical frame. The framework may be suitable on a general level for information systems development but the action research approach does not allow such generalization at this stage as the research is coupled so closely to the real world situation it was derived from. This coincides with the point put forward by Susman and Evered (1978), as to that the framework can work in accordance with all mobile learning initiatives but it is not a quality inherent to the research approach used.

Further, while conceptual modeling provide a useful way to represent a mobile learning initiative, it is just a model, and not an “answer” to sustainability. The idea as such, put forward by Ulrich (1998) is rather to reflect on ways in which people fail to consider the relevant parts. A theoretical framework can be used to communicate and represent something, while the ability to understand things better to improve the situation with regard to sustainability is ultimately placed on the individual researcher.

Moreover, a problem with the use of models is that many situations can be hard to model accurately. There are many attributes to consider, and many of them have intricate relations. More research is needed to give a more comprehensive solution to this delicate problem and this is merely one attempt in that direction.

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Publication V
A Meta-model Describing the Development Process of Mobile Learning

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Abstract

This paper presents a meta-model to describe the development process of mobile learning initiatives. These initiatives are often small scale trials that are not integrated in the intended setting, but carried out outside of the setting. This results in sustainability issues, i.e., problems to integrate the results of the initiative as learning aids. In order to address the sustainability issues, and in turn help to understand the scaling process, a meta-model is introduced. This meta-model divides the development into four areas of concern, and the life cycle of any mobile learning initiative into four stages. The meta-model was developed by analyzing and describing how a podcasting initiative was developed, and is currently being evaluated as a tool to both describe and evaluate mobile learning initiatives. The meta-model was developed based on a mobile learning initiative, but the meta-model itself is extendible to other forms of technology-enhanced learning.

Keywords: development process, meta-model, mobile learning

11.1 Introduction

The focus on mobile learning has increased during recent years, and there is a rapid growth in research initiatives aimed at developing and deploying portable technologies to support learning (Taylor et al., 2006). Mobile learning has grown from a minor research interest to a set of significant activities in schools, workplaces, museums, cities, and rural areas around the world (Sharples et al., 2008). The current mobile and wireless technologies have reached a level of maturity and ability that makes it possible to support a wide variety of learning activities.

A concern is that few of the mobile learning initiatives (i.e., and the information system to follow) are ever developed into actual learning aids that are in wide use (Keegan, 2005). In order for mobile learning to prove its educational and scientific value, more research initiatives need to develop into substantial results and tools that are used in massive scale. Naismith and Corlett (2006) present a retrospective where they look back on the papers published at mLearn 2002 to 2005, and they find several challenges related to development and integration of mobile learning. In this paper we summarize issues similar to those found by Naismith and Corlett as sustainability issues – cases where the mobile learning simply does not fit the intended use and environment.

To address the challenges of mobile learning, this paper introduces a meta-model that describes the evolution and development accordingly. There are many uses for such a model, for example to guide the development of new initiatives, or to evaluate and understand existing initiatives. The meta-model introduced in this paper describes the life cycle of a mobile learning initiative using four stages, and each of these stages are divided into four
areas of concern. The meta-model consists of a sequential life cycle where each stage is iterative. The sequential evolution is referred to as scaling and the iterative process as the process of reaching equilibrium. Scaling and equilibrium are important in order to reach sustainability.

This paper uses the term mobile learning initiative to describe any research activity that aims to investigate the use of mobile learning and develop new ways to learn using portable technology. The rest of the paper is organized as follows. Section 11.2 introduced the meta-model and all its parts. Section 11.3 presents an analysis of a podcast initiative using the meta-model. Related work is presented in Section 11.4 and the paper is concluded by a brief discussion of the findings and future research efforts in Section 11.5.

11.2 A Meta-model for Development of Mobile Learning

In this section we introduce the meta-model and describe it. The model is divided into four stages that show the life cycle of a mobile learning initiative, and each stage can be illustrated using four areas of concern. These areas of concern describe what can be seen as the different problem areas that must be addressed. During the life cycle, different areas of concern will be in focus, but each stage in the life cycle is made up from all the areas, even if they are not in focus. In this section, we begin by addressing the four stages, and then the four areas of concern. We then give an account of the concept of focus, and how it is used in the meta-model.

11.2.1 The Stages of the Life Cycle

The life cycle of a mobile learning initiative consists of four stages: Idea, Trial, Project, and Release. Depending on the outcome and the scope, it can be limited to fewer stages, but in the general case, we assume that the aim of an initiative is a release in a “production” environment. Figure 11.1 shows the four stages of the life cycle.

Everything starts with an idea. This idea can be seen as a vague notion of what, who, and how. How can a mobile device be used as a learning aid, how should learning be transformed onto this mobile device, who is the intended target group, and so on. The major role of the Idea stage is to establish these concepts, and to verify them. Valid questions are whether the mobile technology is available and accessible, if the learning activities can be transferred, will the learning appeal to the intended target group, and so on. In essence, the Idea stage is about forming an understanding. The product of the Idea stage is a description of a trial, with specific variables to test.

The major role of the Trial stage is to determine whether or not a particular idea works in a specific setting. The Idea stage established a number
11.2 A Meta-model for Development of Mobile Learning

of things, and the Trial stage is the first proper test of these. The Trial is carried out with a distinct user group, and the focus is on figuring out what works and what does not. One could for example measure how well the learning translates to the actual technology, or how well the learning works with respect to the intended target group. The output of the Trial stage is a description of a project with specific goals.

The Project stage is a more formalized and realistic extension of the Trial. A Project, in this context, is formally defined with stated prerequisites and a goal. Generally, a Project require more funding than an Idea and a Trial, and a project application could serve as the formal definition. The goal of the Project stage is still to understand if the idea works or not, but now in a setting that is much closer to the intended setting with a larger number of participants. Another important goal is to study how the participants interact within the Project, for example producers and consumers of learning. The outcome of the Project stage should be a description of how the idea should be integrated into a real setting, and how to be “released”.

The Release stage occurs when the Project ends, and is the release of the outcome of the mobile learning initiative. This outcome is deployed as an actual “product”.

The evolution that happens within the life cycle, here depicted in stages, is a sequential process. Once the Idea stage ends, the Trial stage begins. Within each stage, there is an iterative process, where things are tested, verified, and rejected or accepted. It is possible to reject an entire stage and return to a previous one.

Two important processes happen during the life cycle: scaling and equilibrium. Scaling is the process of moving from one stage to the next. For example, using the findings from the trial to prepare a project is the scaling from Trial to Project stage. Finding equilibrium is the process of reaching balance within a stage. Equilibrium is simply a state that is reached when everything “works”. The goal of the iterative process within a stage is to reach equilibrium. Scaling and equilibrium are discussed in more detail in Section 11.2.4.
11.2.2 The Areas of Concern

The important evolution that occurs throughout the development process happens within the stages. A mobile learning initiative can be defined by four areas of concern: Technology, Learning, Social, and Organization. These areas, as depicted by Figure 11.1, are interconnected and of equal importance. A change to one of them will affect the others and you cannot ignore any of them.

The Technology area involves all the technology needed to realize the initiative. This includes hardware and software, for example portable devices, servers, blogs, etc. Technology is often perceived as the focal point and the limiting force of any mobile learning initiative, and it is an important part. This is the reason why technology forms an area of concern.

The second area of concern is Learning. It is separated from technology since the technology is there only to facilitate the learning, not to be the center of it. In a similar manner, its focus is only on the translation of the learning activity to the mobile device in this area, and not on the producers and consumers of learning. Since to enhance and/or improve learning is the goal of any mobile learning initiative, it is important enough to constitute its own area: How will people learn, what are the important characteristics of the learning, how can a learning concept be transformed into something suitable, etc.

The third area of concern is the Social. This includes the people involved in the process, and the parts they play. Learning happens in a social context, and even if it takes place via mobile devices, there will be social interplay. In order to create a working mobile learning initiative, it is very important to understand how the people involved “work” and what they want.

The fourth and final area of concern is the Organization. Any mobile learning initiative is controlled by rules and regulations; this is the main function of the organization, as well as to provide support and infrastructure, practical and pecuniary. Any mobile learning initiative will exist within one or more organizational settings, each complete with agendas, policies, politics, etc. In order to work within these organizations it is vital to understand the setting well enough to be able, at least, to coexist with it.

The four areas together form a complete picture of the mobile learning initiative. However, this complete picture can be difficult to grasp. To deal with this difficulty, the model uses focus.

11.2.3 Focus

During the evolution, focus will shift from area to area, and can at times include more than one area. Hence, focus means that the primary objective at the time is to improve the area(s) addressed. The other areas are still present and affect and are affected by the work on the area that is focused. Imagine a camera lens that zooms in on different parts of a situation. The focus will move from one area to another, revisit, and discover if the
situation has changed. In using the metaphor of a camera, the process of mediation between the areas is easier to understand. One area might be the focus of attention at a particular time, but the other areas are still present in the peripheral vision. The part that is focused dominate the view, but events outside of the focus can still affect the part being focused and vice versa. However, it is possible to see all four areas at the same time, but only by sacrificing the level of resolution. Figure 11.2 illustrates focus on the Social area of concern.

Each stage of the evolution is an iterative process. Changes to something will spill over and affect other things, and this process will continue until the stage reaches a state where it can be considered “good enough”. The focus shows where the initial changes are most likely to happen, and what is to be formed and shaped during the stage. For example, in the Idea stage there are generally vague ideas about the “how”, “what”, and “who” of the initiative and a focus on technology. The main objective is to evaluate and evolve the technology to a point where it supports the goal of the initiative. This in turn means that technology will shape and be shaped by the other areas of concern.

In each stage of evolution, one or a few areas dominate the focus. Applying focus is a way to handle the increasing complexity of the mobile learning initiative systematically. A simple way to describe the areas of concern is that each area adds an additional layer of complexity, i.e., factors to consider. The more complex the initiative gets, the more of these there are to worry about. In the first two stages, the focus is on getting the technology to work and dealing with the learning task or activity. Once these two are on acceptable levels, the later stages focus on introducing producers and consumers i.e., the social aspects of the learning activity, as well as the organizations that benefit and support the initiative, financially and with other means. These generally are far more complex. Figure 11.3 depicts this change in focus during the evolution.

The purpose of focus in the meta-model can be seen as threefold. First, focus is used to break down a complex whole into smaller parts that are easier to grasp and work with. Second, focus allows a working order, where the area focused is the development target. It is not the only part being developed, but it will be the main objective. The third purpose is that focus illustrates the evolution process by indicating where the main difficulty and complexities will happen in the initiative.
11.2.4 Scalability, Sustainability, and Equilibrium

As discussed in Section 11.2.1, scaling is the process that happens between stages in the life cycle. Scalability refers to an initiative’s ability to scale. Sustainability is a measure of how well an initiative solves the problem it was intended to solve and how well it fits the setting. An initiative that results in a learning aid that is in use will have a high sustainability while an initiative with low sustainability will fail. Scalability affects the sustainability.

Scalability can be considered as the initiative’s ability to grow. This expansion, in respect to all the four areas of concern, should be able to handle different types and groups of users and organizations with everything that are entailed for the areas of concern. There will always be a point at which scalability stops making sense, i.e., a largest rational organization it can scale to or a “market” that can be “controlled”. Using this description, scalability can be defined as the ability to reach sustainability at an evolutionary stage. The more stages at which it reaches sustainability, the more scalable the initiative is. In this respect, saying that a mobile learning initiative is scaled to Project stage simply means that it found balance at the stages of Idea, Trial, and Project. The components (areas of concern) were in unison with each other at each stage.

The four areas of concern will have different importance, i.e., focus, during the evolution of a mobile learning initiative. But, it is still important that the areas get at least noticed and are in balance at each stage. When a change is done, it will affect the other areas in different ways, and these may need to react and adjust. When there is no longer a need for reaction and adjustment, the stage has reached a state of equilibrium. If a change causes too much friction between the areas it might result in that equilibrium can never be reached, and the change needs to be reverted. This can be difficult and even impossible and if balance is not reached the initiative might “self-destruct”.

Within each stage, equilibrium signifies a stable state. Reaching that
11.3 Using the Meta-model to Analyze a Podcasting Initiative

This section presents a Podcasting initiative and an analysis of the initiative using the metamodel. In this case we use the metamodel to understand an existing initiative to illustrate how it can be used. As a visiting researcher at COSC, the COmputer SCience Research Group, during fall of 2006 and spring 2007, the first author of this paper had first hand experience of the initiative and it is further described by Bell et al. (2007), and Wingkvist and Alexander (2007). The aim of the Podcast initiative was to provide supplementary material to the courses held at Canterbury University, Christchurch, New Zealand, that students could use while doing other activities.

The Podcast initiative started with the idea to use podcasts to supplement the learning experience, which a student is expected to have in a course. The initiators used the technology themselves and imagined that students would find it beneficial to be able to refresh course work while doing other activities, such as household chores, exercising, and commuting to and from university. The idea grew into a number of concerns, especially about the technology. Was it in wide use, would the students accept it, and so on. In order to answer these concerns, and to better understand the setting, a questionnaire was given to students. The questionnaire measured several concerns, for example access to digital audio players and podcast usage. The result provided enough understanding to reach equilibrium at the Idea stage and helped formulate a Trial. As suggested by the model, the major focus was on technology.

In order to test the idea, podcasts were used as part of two Computer Science courses, with approximately 400 students. The two courses offered weekly podcasts with varying contents, ranging from reading aloud from the text book to interviews styled sessions with other lectures, business people or researchers in the field of Computer Science. In order to measure how well received the podcasts were, a questionnaire and other data sources, such as download logs were used. Similar to the model, the focus was on how learning could best be facilitated by podcasts, i.e., how to structure
the content.

The Trial targeted Computer Science students and the initiators created the podcasts. In order to test how viable the idea really was, other disciplines, students and lecturers had to take part. The Project stage extended the initiative to cover courses within four other disciplines, i.e., Japanese, Economics, Music, and Educational studies, with about 400 students. This was done in order to test how well podcasts suited other disciplines, for example languages studies, and how easy it was for lecturers to produce and publish podcasts. It was also important to test how well the technology was accepted by both lectures and students that did not study Computer Science. While part of the focus was still on Learning, the major focus was on the Social issues of how producers and consumers of learning work together using podcasts.

This analysis shows that the meta-model can be used to describe the project in terms of stages and focus. For a more detailed analysis of the podcasting initiative using the meta-model, see Wingkvist (2008).

### 11.4 Related Work

Software development (SD) models are used to structure, plan, and control software development. There are a number of such models, and they can generally be divided into sequential, iterative, or a combination. The sequential methods are divided into separate phases, which are carried out in order. An iterative method is generally divided into smaller phases, and the full set of phases is iterated over. Examples of sequential models and iterative models are the waterfall model (Royce, 1970) and prototyping respectively (Larman and Basili, 2003).

Instructional design is the practice of creating instructional content and tools to help facilitate learning activities. ADDIE (Allen, 2006) is a generic and simplified instructional system development (ISD) model. The model is divided into five phases, Analyze, Design, Develop, Implement, and Evaluate. ADDIE is a sequential model where the outcome of the previous phase is the input of the next step.

The evolutionary life cycle model introduced in this paper shares many similarities with both SD and ISD models. A difference is that the model introduced in this paper exists on a meta-level, and SD and ISD models are used on a more pragmatic level and form the tool set used to deal with the areas of concern. For example, the Learning area of concern says nothing about how the learning should be designed and implemented, but rather that learning, technology and the other areas of concern are connected. Similarly, the model introduced in this paper models the evolution, but SD and ISD models can be used for each step of this evolution. This is similar to the Unified Process for software development (Sommerville, 2006), which consists of several phases, each with several iterations, and many of the phases have their own set of methods and models.
11.5 Conclusions

Several frameworks and meta-models that aim to aid and improve the development and understanding of mobile learning initiatives have been published. Many of these address only on one or a few aspects of mobile learning, and in this section the interest is only on frameworks and meta-models that intend to capture the entire development process.

Taylor (2004) presents an evaluation framework for the MOBIlearn project that illustrates to some extent the evolution and the order in which different areas are in focus. She starts from a technological standpoint and continues with pedagogical considerations, and socio-pedagogical perspectives, while acknowledges the influence of the data counter flow. The ideas behind this framework resemble those of the meta-model presented in this paper, though only from an evaluation point of view.

Laouris and Eteokleous (2005) make an attempt to create a systematically complete framework to define mobile learning. This framework is expressed using mathematical notation and use functions to describe relations and dependencies between elements, e.g., content, IT, learning environment. In terms of intent, this framework is similar to the meta-model, but uses a completely different approach to describe the elements and the development process.

Vavoula and Sharples (2008) propose a framework built on holistic and systematic evaluation divided in three levels of granularity, i.e., micro, meso, and macro, to guide the data collection when designing, implementing, and deploying a mobile learning initiative. Thus, the requirements analysis persisted throughout the initiative’s life cycle, and covered all three levels of analysis. They conclude that mixed methods are increasingly present in the design of evaluation activities for mobile learning. The core approach of continuously addressing granularity and employing strategic evaluation compare well to the view of stages and focus of the meta-model in this paper, but the pragmatic approach differ since the meta-model can provide a main focus for each development stage, as well as to what to evaluate.

11.5 Conclusions

In this paper we present a meta-model that is used to describe the life cycle and development of mobile learning. The meta-model can be used for example to guide new development efforts or to evaluate existing mobile learning initiatives. The paper further presents an analysis of an existing initiative using the meta-model.

The main contributions of this paper are the life cycle model and how it relates to the concepts of equilibrium, scalability, and sustainability. By linking the sequential evolution, i.e., the scaling of a system, and the iterative process within the stages, i.e., the process of reaching equilibrium, the sustainability of a mobile learning initiative can be defined as being able to scale to and reach equilibrium at the last stage of the life cycle. A sustainable system is a scalable system. Another important concept is focus
and the way focus allows for targeting different areas of concern during the evolution. The metaphor of a camera lens makes it easier to understand focus and how to deal with the complexity involved when undertaking a mobile learning initiative. This provide an intuitive notion of what happens during a stage, and how one should consider all areas of concern.

The meta-model is currently being used to evaluate and understand other technology-enhanced learning initiatives. We are interested in using it to study initiatives that do not use portable technologies to see how well the meta-model works in those cases. There is nothing in the meta-model that specifically ties it to mobile learning, so we believe that it is general enough to cover other forms of technology-enhanced learning as well. We are also interested in using the meta-model to guide the development of a new initiative for a more “hands-on” experience.

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Dealing with Stakeholders in Mobile Learning: A Study of Three Initiatives

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Abstract

There is a need to reach viable design for initiatives in mobile learning and researchers are faced with a magnitude of factors to consider. The work to identify and access stakeholders and acknowledge their requirement is a difficult task. Most mobile learning initiatives often follow an evolutionary development process where the system is constructed, evaluated, and refined in increments. During this process, the stakeholders and their needs might change, so even if there was an initial understanding, it might not be correct after one or more increments. In this paper we studied three initiatives with a focus on how they dealt with stakeholders during the development process and finds that the three initiatives deal with stakeholders in an on-demand fashion. New groups of stakeholders are considered when needed, and this leads to a development process that is a mix between sequential and evolutionary, which results in inflexible system solutions. In order to improve on this, stakeholders need to be regarded in a more inclusive fashion, where they are considered as part of the entire development process.

Keywords: development process, mobile learning, stakeholders

12.1 Introduction

Mobile learning has grown from a minor research interest to a set of significant activities in schools, workplaces, museums, cities, and rural areas around the world, meaning that the knowledge base on how to develop and integrate mobile learning is rapidly increasing (Kukulska-Hulme et al., 2009). What was perceived to be a more technological issue, with the main task being, to develop the mobile technology and to get users to use it, is shifting more towards, to understand and enhance the integration per se, including dealing with stakeholders. Technology will always be an important part of mobile learning since it is the prerequisite, but more weight in future efforts is to be placed on to understand pedagogic and people-related factors. These factors can often be found to be the most problematic aspects to handle when to develop and integrate mobile learning in a specific setting. Although difficult, these aspects are not unmanageable and some attempts have been made to increase the body of knowledge in this area, targeted specifically to the mobile learning community (Cobcroft, 2006, Traxler and Kukulska-Hulme, 2005). McFarlane et al. (2008) note that most of the papers presented in the field of mobile learning is based on small single-case studies with little to no comparison made, with few trying to extract valuable insights from a more extensive data set.

Mobile learning as a new field of research might on one hand need to read up on lessons learned from more established disciplines such as Computer Science, Human Computer Interaction, and Information Systems, but on
the other hand also build up its own knowledge base and create some distance to other research interests according to Vavoula and Sharples (2008). Experience based on trial-and-error practices need to be consolidated, and in turn able to be incorporated into future research conduct (Naismith and Corlett, 2006). Mobile learning researchers exist in a delicate development zone, where stakeholders and their requirements need to be dealt with accordingly. Parsons et al. (2006) state that the exist a need to manage all stakeholders involved and honor the integrity of all parties, in order to reach viable design of a mobile learning initiative. Wingkvist (2008) suggests and separates technology, learning, social, and organizational aspects as the main four areas of concern that need to be addressed in respect to the development process of a mobile learning initiative to reach just that.

The focus of this paper is on how three mobile learning initiatives dealt with their stakeholders and requirements. Sharples et al. (2008) mention that this type of analysis is not commonly found in the field of mobile learning and consequently of great interest despite the large number of research initiatives initiated over the last years as Taylor et al. (2006) acknowledge.

The rest of the paper is organized as follows. Section 2 discusses development process and stakeholders, and why these are important and related. Section 3 presents the three initiatives, and also contains an analysis of the initiatives according to technology, learning, social, and organization aspects, and their evolution, respectively. Section 4 contains a discussion, and Section 5 concludes the paper.

12.2 Theoretical Foundations of the Development Process and Dealing with Stakeholders

The first author, coming from an Information Systems background, can confirm via the study, many of the traditional people-related issues related to dealing with stakeholders in a development process perspective. However, managing the complexities involved in developing and integrating mobile learning still needs to be enhanced, as it is a unique and young research field. The uniqueness comes from the learning aspect, as it is not one-to-one in respect to a business process, which is often the core aspect in an Information Systems development.

However, Sharples (2000) state that the actual development process in a mobile learning initiative is closely related to that of Information System development and shares most of the characteristics. Any system development process can very roughly be described as finding out what to do, do it, and verify that it was done. The steps are often elaborated and can be done sequentially or evolutionary. In a sequential model, for example the "waterfall model" (Royce, 1970), every step is carried out fully in sequence, and returning to a previous step can carry large penalties (for example an
increase in time or cost or both). While, in an evolutionary model (Boehm, 1988), the development happens in increments that go through the steps of the sequential model. Each increment refines the previous, until a satisfactory result is produced. Examples of evolutionary models are Rapid Application Development (RAD), Extreme Programming (XP), and Agile development.

Any mobile learning initiative has a number of stakeholders, persons or groups that will be affected by it directly or indirectly. According to Barker et al. (2005) the stakeholders of a mobile learning initiative are: the learners, the teaching staff, the system designers and engineers, along with device vendors, and the institution representatives that oversees and “owns” the initiative. Hence, stakeholders can be end-users, who interact with the system directly, designers responsible for the architectural framework, engineers managing this and related systems, the person who commissioned the system and so on. Each stakeholder holds evidently a stake, a need or a want, in the system that should be captured. The needs and wants are referred to as requirements and finding them is a co-operative process of learning in which requirements are explored, classified, prioritized, negotiated, and documented according to Sommerville (2006). Finding the correct stakeholders and the most important requirements is crucial in any system development process.

As mentioned, sequential and evolutionary processes differ in how they handle the stakeholders during the development process. A sequential process model deals with requirements at the start and after the first phase the requirements are locked down. In an evolutionary process model, each increment deals with stakeholders, and thus provides a much closer feedback loop between developers and stakeholders.

Many mobile learning initiatives follow an evolutionary development process, with changing and addressing stakeholders in turn. In order to better understand how this change is handled, this paper studies three mobile learning initiatives with respect to how they dealt with their stakeholders. It is important to study both how the stakeholder group changed during increments as well as how stakeholders were included in the evolution.

### 12.3 Overview of the Study

In this section three mobile learning initiatives are presented in chronological order, which the first author of this paper had access to during recent years, being a researcher at CeLeKT, Center for Learning and Knowledge Technologies, at Växjö University, Växjö, Sweden and a visiting researcher at COSC, the COmputer SCience Research Group, at Canterbury University, Christchurch, New Zealand. This section introduces the three initiatives (unit of analysis) that are later discussed in the paper. Whereas this form of field study is a well-established form of research (Klein and Myers, 1999), the result is a product of interpretation, and indicative rather than
conclusive. It should however be a valuable contribution to, and added to the pre-existing knowledge base in the community of mobile learning.

First, each initiative is briefly presented with a focus on the purpose, the target group and how it was carried out. Secondly, the same initiative is analyzed in relation to the four areas of concern, addressing in turn technology, learning, social, and organization examples found. In short, the aspect of technology focuses on the technology used to support the learning, while the learning aspect focuses on how learning objectives were translated to the system platform. Next, the social aspect studies how for example students and teachers interact with each other and the technology, and lastly organization is about how the new learning activity fits into the existing setting. The four perspectives, areas of concern, are further explained in Wingkvist (2008). This is followed thirdly by an account on how the evolution happened for the initiatives. This section describes the different phases that the initiatives went through and how the initiatives changed in relation to stakeholders between these increments.

12.3.1 The AMULETS Initiative Introduced

AMULETS (Advanced Mobile and Ubiquitous Learning Environments for Teachers and Students) (Kurti et al., 2007; 2008) is an initiative that explores how teachers can develop and implement novel educational scenarios that combines out-doors and in-doors activities using mobile technologies.

Students are given a number of tasks, missions, to accomplish. The learning is centered on these tasks as well as the extra skills required to accomplish the tasks, for example collaboration and problem solving. The students have classroom activities before they are given the tasks, and the mobile technologies as well as teachers support the students during the tasks. The tasks are then followed up in the classroom once again to strengthen the learning loop.

The students use the mobile technologies to access information and interact with the environment using location information or special codes. They can also collaborate with other groups by sending instant messages and rich media files. The devices allow the students to document the environment by taking photographs or recording audio and video. The recorded data is automatically stored and tagged with location information so it can be displayed on interactive maps. This allows for the discussion and exploration to continue in the classroom and the data can also be used to support future outdoors tasks (follow-up studies, for example).

AMULETS was divided into three trials that took place in 2006 and 2007. The first two trials were conducted in collaboration with an elementary school in Växjö and the students were 4th and 5th graders (children 10–12 years old). The third trial was done in collaboration with the teacher’s education program at Växjö University and their students (18–35 years old). The first and third trial explored the nature, and tasks included identifying and measuring the age and height of trees in the forest. The second trial
focused on local history and missions included decoding Roman numerals and identifying the tools a blacksmith used in a specific historic setting.

12.3.2 The AMULETS Initiative Described by the Four Areas of Concern

Technology: AMULETS uses two-dimensional visual codes (i.e., semacodes) and positioning information. A mobile device, a Smartphone, is used to scan the semacode (often by taking a photo of it using the camera function). Software on the Smartphone translates the semacode into a web address, a URL, that points to a resource. This resource can for example be a video that is displayed or a registration that some specific goal has been achieved. One use of semacodes is to start each mission; the students scan the semacode and as a result get an animated video telling them what the mission is.

Positioning information is captured using a Smartphone with a GPS. This information is mainly used to annotate recorded material, such as movies or pictures, so it can be placed on a digital map. This can in turn be used for post-activities in the classroom.

The second and third trials used a portable computer with a wireless (i.e., GPRS) Internet connection, and it was used to find information using various web sites. In AMULETS custom-made software was used both for clients and servers, to support the mobile devices.

Learning: The learning activities were implemented in a task-oriented way. The students were given missions that they needed to accomplish. The missions were rated, so students scored points and this turned the learning into a game with competition between the teams of students. A mission can be to identify a tree or to decode Roman numerals on a city building. Apart from learning about the actual tree or Roman numerals, the students should also learn how to approach and solve problems, and how to negotiate and collaborate in groups. In many cases the learning was supported by pre- and post-activities. For example, in the first trial, the students took part of a pre-activity that taught them the various tree types and how to identify them. The skills they picked up during this activity were then used in nature during the missions.

Social: The students were divided into groups and had to share the smart phones within the group designated to. One of the goals was to learn how to collaborate within the group. In the later trials, the students also had to collaborate between groups, when one group was inside and the other outside and had access to different sets of information. For example, one group had access to the actual Roman numerals and the other group had access to instructions on how to decode them, which leads to a need to communicate with each other.

Organization: AMULETS was not initiated by the educational institutions, which make up the setting, but rather as a research oriented initiative to explore the potential of mobile technologies in learning activities. Own-
ership and operation still remain with the research group. However, during one of the trials university students that are studying to become teachers were used as subjects. This can be seen as an attempt to educate the teachers of tomorrow about the possibilities of mobile learning, connecting it to potential future partners in the educational sphere.

12.3.3 AMULETS in Terms of Practice and Progress

AMULETS was divided into three trials, and each trial represented a major change to the initiative. The first trial was carried out at an elementary school in Växjö during spring 2006. Students were divided into teams of roughly four children each and each team was equipped with two smart phones, one for controlling the game and one for content creation. The learning activity itself was divided into three stages, a pre-activity, a field activity and a post-activity. The pre-activity was conducted in the classroom and taught the students about the forest, for example how to identify trees in respect to species. The teams conducted the field activity over two days, one team at a time. During the post-activity in the classroom, the students presented the material they had produced (photos, audio, video) during the field activity, using digital maps to associate the material with locations.

The members of a team had to collaborate to solve the tasks they were given. The material the students needed to solve the tasks was either available from the mobile device, or from the pre-activities in the classroom or teachers in the field.

In the second trial, each team was divided into two subgroups. One subgroup was assigned to perform tasks in the field (outdoors) while the other subgroup performed tasks at a museum (indoors). The two groups that formed a team had to collaborate both within the groups as well as between the groups to carry out the tasks assigned. Each of the two groups within a team had five members.

The outdoors group was given three smart phones. Similar to the first trial, one phone was for control mechanism and the other for content generation. The third phone was for instant messaging between the two groups. The indoors group had access to a portable computer with a wireless (GPRS) Internet connection as well as a smart phone for photography and instant messaging. The two groups communicated by sending messages and photographs. A student from the teacher-training program at Växjö University supervised each group.

Each of the two groups within a team had access to different information and had to collaborate to perform the task assigned. For example, the outdoors group was asked to find a specific building with Roman numerals and decode them. The indoors group was given instructions on how to decode the numerals. So, in order to solve this task, the outdoors group had to photograph the Roman numerals, send the photograph to the indoors group. The indoor group then used the instructions to decode the numbers...
and sent the decoded number to the outdoors group, who then scanned the correct code (see Section 4) and “solved the puzzle”.

Each group in the second trial was assigned either to the field or the museum. In trial three, it was changed so that groups swapped during the activity and tried both roles. Another change compared to the second trial was that the number of devices was reduced. The idea was to make the communication between the groups more efficient, so communication was mainly carried out using recorded audio and video or photographs. Another change was that specific communication codes were used to send media to the indoors group. The task of the third trial was similar to the first, i.e., to identify trees.

AMULETS changed in several ways over the three stages. The collaboration changed from between members within a team to between members within subgroups and between subgroups of a team. The activity changed from being sequential both within a team and between teams to parallel between the two groups of a team and the different teams. Another change was how the individuals communicated. In the first trial, everyone could talk to everyone, while the second and third trial relied on messaging and recorded material.

12.3.4 The Podcast Initiative Introduced

The Podcast initiative is a research incitement at Canterbury University, Christchurch, New Zealand, aimed to utilize the inherent mobility and provide supplementary material to a number of courses in various disciplines during 2006 and 2007 (Bell et al., 2007, Wingkvist and Alexander, 2007). Podcasting is a way of providing digital audio or video content. The digital audio or video content is stored at a remote server, and made available for download using web syndication technology. Special software is used to subscribe to podcasts and new content is automatically downloaded to a local client when it is published.

By good use of the mobility of digital audio players and the possibility to listen to audio-only podcasts “on the go”, students can be offered a way to extend the number of hours they study without imposing on the time they need for other activities such as household chores, commuting, and exercise.

Students studying Computer Science, Japanese, Economics, Music, and Education were provided supplementary podcasts with varying contents and formats. For example, while one of the courses used 20 minute long podcasts with one presenter, the podcasts for the other course varied in length (20–60 min) and sometimes used two presenters. Often the past week’s material was reviewed, there were discussions and commentary, interviews, questions and answer sessions, future topics were addressed, and the students were reminded about upcoming events and deadlines. While experimenting with the content of the podcasts over the length of the courses, complete one-to-one sound uptake of lectures were also provided as podcasts, just to see how many students would download those.
The initiative assumed that students had access to devices that they could use to listen to the podcasts, for example portable audio players (mp3 players), mobile phones or computers. It was up to the students to subscribe to, download and listen to the material. In order to not affect the students that elected not to use the podcasts, all the material was supplementary and not required listening to pass the courses.

12.3.5 The Podcast Initiative by the Four Areas of Concern

Technology: The podcasting initiative used podcasting technology to supplement higher education. A podcast is nothing more than a digital audio file, which can be played on a number of devices, ranging from computers to mobile phones and portable digital audio players (mp3 players). In order to make it easier for the students to remember to download the digital audio files, special software and aggregators (such as iTunes) are often used to allow users to “subscribe” to podcasts, i.e., to automatically download new files to the players and keep track of which podcasts the student has already listened to. Such software solutions are widely available. The podcast initiative assumed that the students had access to devices so they could listen to the podcasts.

The technology required to produce and publish podcasts is also simple. A microphone and software to record and produce a digital audio file of the right format is required. Such software is widely and often freely available.

Learning: A major learning goal of the podcasting initiative was to offer the students the possibility to refresh course material while doing everyday activities such as household chores or exercising. In order to do this, it experimented with a number of different formats of the podcasts. This initiative focused on supplementary material, for example question and answer sessions, interviews, in-depth discussions of certain topics, and so on.

Social: The social aspects of the podcasting initiative mainly concern the production of podcasts and the interaction between students and teachers using pre-recorded material. It is generally hard to get feedback on material posted in podcasts. The students listen to them “on the go” without access to ways to provide feedback, and often forget what they wanted to say before they gain access. The podcasts produced did include a current information segment, which reminded students about upcoming deadlines, presented news, and so on. This helped to build a connection.

Organization: The Canterbury University was the setting of the Podcast initiative. Issues that was dealt with in this context was for example access to recording equipment and studios in order to produce new podcasts and support for the students and lecturers, both in terms of technical assistance and in resources (money and/or time).
12.3.6 The Podcast Initiative in Terms of Practice and Progress

The podcast initiative aimed to supplement higher education with audio-only material that students could use to refresh course work while doing other everyday activities such as household chores or exercising. The evolution of the podcast initiative happened in three stages, with an increase in scope in each stage.

At the time the initiative was initiated (autumn 2006), podcasting was a common phenomenon. The first stage investigated how known and accepted podcasting was within the student body as well as how many had access to portable digital audio players. Students were also asked if they would listen to educational podcasts and, if so, what format they would prefer (recorded lectures, topical issues, etc.).

The second stage introduced supplementary podcasts for two first-year Computer Science courses. The two courses offered weekly podcasts. One of the courses used 20 minute long podcasts with one presenter, while the podcasts for the other course varied in length (20–60 minutes) and used two presenters. Both used a similar format; the past week’s material was reviewed, there were discussions and commentary, future topics were discussed and the students were reminded about upcoming events and deadlines.

The third stage expanded the number of courses and disciplines that used podcasts by including Economics, Education, Japanese, and Music. The initiative also received funding from the university at this point. The format of the podcasts was similar to the previous stage, i.e., both lecture (one-to-one sound uptake) and supplementary podcasts. The use of podcasts was evaluated throughout the initiative, primarily by questionnaires.

The podcast initiative used a careful, feedback-driven process as it evolved between the stages. In each stage, feedback was gathered and this feedback was used to improve upon the current stage and to plan how to increase the scope while still taking the feedback into account. For example, the lessons learned about the format of podcasts from stage two was preserved as a set of guidelines that were taken into account in the third stage.

12.3.7 The Skattjakt Initiative Introduced

Skattjakt (Spikol, 2009, Spikol and Milrad, 2008) (Treasure Hunt in English) is a mobile game inspired by treasure hunt activities and orienteering. Orienteering is a traditional Swedish running sport that involves navigation with a map and compass. The initiative was originally conceived and developed to encourage young people to get physically active.

The game is generally a mystery set in a specific scenario that needs to be solved. A strong narrative often drives it and the playing field is set across relevant locations. The specific puzzles that need to be solved represent the learning and should suit the mystery and the locations. For example, the first instance of Skattjakt involved the ghost of a local countess and was
set around the castle where she originally lived. The game aimed the teach students about local history.

Students playing the game were divided into teams, and several teams can compete against each other. Each team is given a map with locations and each location is a problem that needs to be solved in order to reveal the next location. An incorrect answer will result in a penalty, a detour, that will increase the time it takes for the team to finish the game/route. Playing the game involved informal map reading skills, problem solving, learning across different domains and collaboration within the team.

Each team is given a mobile phone that they use to play the game. The phone displays an interactive map that players can zoom and pan out on. When a team encounters a problem they enter a code, and the application running on the phone presents the problem description. The software provides clues, and an answer (correct or incorrect) will reveal a new location on the interactive map that the team needs to find next. The teams can also document their surroundings by taking photographs or recoding audio and video. The recorded material will automatically be stored and tagged with location information. The routes taken and the gathered material are presented on a digital map that can be used for post-activities after the game is finished.

Skattjakt has been played a number of times between 2007 and 2008. During the pilot children aged 12–16 played the game. Some of these children were then selected to develop a new game (mystery) that was later played by other students. This was then repeated and Skattjakt has now evolved into the mLearn2go platform that can be used by any teachers to create new games suitable for their curriculum.

12.3.8 The Skattjakt Initiative by the Four Areas of Concern

Technology: Skattjakt uses mobile phones with custom made software to display an interactive map, deliver clues and puzzles. The technical platform was at first kept to a minimum and did not use features such as semacodes or GPS for positioning. Instead it uses numeric input for solving the puzzles. By using a minimal technical platform, a wider range of mobile devices can be used. However, later versions of the software included support for more advanced features (such as semacodes and GPS). The students could access audio clues to help solve the puzzles.

When students encountered a puzzle or a landmark there is a numeric code that they need to enter into the phone. In a similar manner, the different alternatives when answering a puzzle all have a numeric code, and the students enter the code that they think is correct.

The students also had access to mobile phones with camera function that they could use to document their experience. The recorded material was automatically annotated with positioning information from the GPS.

Learning: Skattjakt uses puzzles and scenarios to support the learning
activities. The students are faced with a number of puzzles that they need to successfully solve. The puzzles are part of a scenario; a story or setting that enhance the learning. For example, one trial used a narrative approach in the shape of a ghost of a real historical figure to teach the students about local history. In order to access the puzzles, the students need to use an interactive map to navigate. So, the students also learn navigation skills and collaboration within the groups.

Social: The students were divided into groups and had to share access to the smart phones. They had to collaborate within the group to solve the various puzzles. In later stages of Skattjakt, the students also became involved in the design of future scenarios and puzzles. As part of this stage, the students interacted with teachers and members of the research team.

Organization: Skattjakt has evolved from the product of collaboration between researchers and a local orienteering club from Växjö to something that includes a complete authoring system, allowing anyone to create content. From an organizational point of view, it has evolved into something that can be integrated into a setting since content can be customized and made to suit particular needs and requirements.

12.3.9 The Skattjakt Initiative in Terms of Practice and Progress

The evolution of Skattjakt can be divided into four stages that happened during 2007 and 2008. The idea behind Skattjakt was to combine treasure hunting and orienteering as a game to encourage physical activity. Students solved puzzles and answered questions at each control/location and this made up the learning part of the game. Each answer revealed a new location/control. Incorrect answers resulted in a detour that in turn extended the route to finish. Teams of students played the game, and each team had access to mobile phones to run the game and to document their experience (photos and video).

The first instance of Skattjakt was a joint collaboration between a research group called CeLeKT — Center for Learning and Knowledge Technologies — at Växjö University, and a local orienteering club. The game was set at and around a local castle and the mystery involved local history and local historical figures. A countess returns as a ghost and needs help to solve a mystery regarding her husband, the duke.

The main change from stage one to stage two was not in the way the game was played or in the technology driving the game, but rather in the design of the game. The second stage game was designed by students (13–15 years of age) at a local school as part of an elective course during the 2007–2008 semester in collaboration with the research team. The students designed a new mystery where the players had to find hidden heat transmitters contributing to global warming that aliens had placed in the city. The new design also introduced ways to sabotage the other teams by forcing them to take a detour as well as power-ups to protect the team from sabotage. These
features played very well during design and testing, but did not translate very well to the actual game play. When playing the outdoors game, players were spread out over the city, and this made the sabotage and power-ups work poorly. The students, who played the game where from other schools in the region and in the same age-range.

Students also designed the game in the third stage and together with their teacher became the driving force of the game design process, and they developed a game concept similar to the board game Cluedo (inspired from the word Clue). This time the game was played as part of a field trip for younger students (9–12 years of age). These students had to perform informal activities, such as obstacle courses or sorting recyclables to collect clues in order to solve the mystery.

Stage four of Skattjakt shifted focus from the design of games to the actual design process. In this stage the requirements specification for an authoring tool that could be used to design and create games was developed. From the specification, prototypes were developed which resulted in the mlearn2go platform that can be used to design, create and run games.

The focus of Skattjakt evolved from focus on a particular game to the design process of future game. The control of the game content slowly shifted from the research group to the teachers and students over the four stages.

12.4 Discussion

Dealing with stakeholders and their requirement is a sensitive task but the most important part of system development, and need to be addressed with delicate hands. In the previous sections, three mobile learning initiatives have been presented and analyzed with respect to four areas of concern, namely technology, learning, social, and organization. The practice and progress (i.e., development process) was also studied and found to be evolutionary for all three of the initiatives.

In an evolutionary development process, the four areas of concern are of-
ten dealt with in the order specified. First the technology should work, then learning is considered, while social and organizational aspects follow. This was previously suggested by Wingkvist (2008) in regard to how to handle the complexity involved when undertaking a mobile learning initiative. The groups of stakeholders are treated in a similar fashion, and included “on demand” when their expertise is needed. For example, when shifting focus to learning, the teachers are included in the process. Figure 12.1 depicts this process. Barker et al. (2005) names five groups of stakeholders to a mobile learning initiative in an educational setting: the learners, the teaching staff, the system designers and engineers along with device vendors, and the institution representatives. When studying the three initiatives it was found that two of these groups, system designers and engineers along with device vendors, were very similar in terms of what effect their requirements had on the system. This paper therefore groups these two into one and only notice four groups of stakeholders.

The four groups of stakeholders are addressed in turn during the development process, and each group can be matched to one area of concern. For example, when the development switches from technology to the learning, the stakeholders in the teacher group are the ones that pose the requirements. This is similar to concept of focus, suggested by Wingkvist (2008) where one area of concern is the focal point at a stage of the development, but with a major difference. Focus mainly considers one area but still keeps the others in the periphery, while the stakeholders are exclusive to one stage. A focused area can affect and change other areas, but the requirements of a group of stakeholders will neither affect nor be affected by other groups in an increment where that group is being considered.

However, the key discovery found in this study is that these three mobile learning initiatives have been dealing with stakeholders by mixing sequential and evolutionary approaches in the development process. It is sequential in the sense that stakeholder requirements are considered once and never changed, but evolutionary in the sense that different stakeholders are considered during different increments. In essence, this result in a system built like a tower, where the requirements of each stakeholder group forms a bricklayer.

Building a system layer by layer, with each layer specifying its own set of requirements can result in inflexible system solutions, as each layer will decide on certain requirements that cannot be change at a later date. For example, if the technical platform does not support video, the learning activity cannot require video. Both teaching staff and learners often find the technology exciting and fun, and pose relatively few requirements on it. It is often viewed as an extra curricular activity and an add-on. However, when the system is to be integrated into the institution, several more requirements are posed, and the inflexible system structure often struggles to meet these. For example, MyArtSpace (Sharples et al., 2008) enabled learners to use mobile technology to explore a museum. The initiative was a success on many levels, but failed to consider some every day practicalities.
of the mobile technologies, i.e., who should pay the traffic fees and who should charge and maintain the mobile devices. This could not be solved within the institutional setting, and the initiative had to be taken over by a company that offers the service for a fee.

12.5 Conclusions

This paper studied three mobile learning research initiatives in terms of purpose, implementation, and evolution. The three initiatives regarded stakeholders differently, and had different strategies to include them in the development process. An important lesson is to not regard the stakeholder groups in isolation but to adopt the concept of focus. All the stakeholders should be considered in each increment, and requirements should be ranked and prioritized. The more important requirements should be acknowledge early, and identification and access to the stakeholders, who can pose them is central for a viable design of a mobile learning initiative. A viable design built on the notion of flexibility, meaning instead of building layer upon layer fixating a system structure, the development process should put more emphasis on understanding stakeholders requirements and work on the integration of the system.

This research should be followed by a study of how the experience gained from the initiatives studied here affects future initiatives. Is there any change in how stakeholders are identified and dealt with during the development process, and how did the development process change in itself. Mobile learning is increasingly in need of the benefits that a knowledge base in this area promises. Alas, the possibility for more research in line with this one, which brings together an extensive data set and draw results based on more than one small-scale study, is sought after. This is mere one effort to understand and give suggestion on how to adequately address the problems that development and integration present in term of dealing with stakeholders and their requirements.

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Publication VII

Sharing Experience from Three Initiatives in Mobile Learning: Lessons Learned

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Abstract

Incorporating knowledge from past experiences is an important part of any development process, as one has to know what worked and what did not in order to avoid repeating the same mistakes. However, many published results in the field of mobile learning focus on isolated technologies or a specific trial rather than to reflect on the overall work practice and outcome. Such reflections can offer maturity to this emerging field of research. This paper presents reflections gained from three mobile learning initiatives that are presented in the form of lessons learned. These lessons learned can serve as considerations for researchers when developing new initiatives.

Keywords: development process, experience, lessons learned, mobile learning, reflections

13.1 Introduction

The mobile learning community has carried on the core idea of Alan Kay and the Dynabook (Kay and Goldberg, 1977), and the phrases mobile learning and life-long learning have been coined as an effect. Taylor et al. (2006) state that mobile learning initiatives are plentiful in numbers and furthermore Kukulska-Hulme et al. (2009) state that in many trials it is suggested that mobile devices can have a positive contribution to learning and teaching. However, mobile learning has yet to make a substantial impact on the way we learn and teach in educational institutions of today according to Traxler and Kukulska-Hulme (2005). Wingkvist (2008) establishes the notion of sustainability in relation to mobile learning initiatives and state its importance in regard to successful deployment of mobile learning in an educational setting. Sustainability can best be described as the ability of a mobile learning initiative to exist within the organization it was intended for, and support it and its goals. She further shows that it is imperative to understand the core implementation, what the technology is supposed to do, and how it can support the learning experience, before starting a mobile learning initiative.

An important means to reach sustainability is to make past experiences, knowledge of what works and what does not work, explicit to the rest of the research community. Explicit knowledge in published work is an important source to seek inspiration from when starting new initiatives. While there are many initiatives within mobile learning and a growing body of research results, many of the published results focus on small-scale trials and their outcome. There is a lack of reflection on the outcome and of the reasons for it (McFarlane et al., 2008). Knowledge based on this type of experience takes time to accumulate and is tough to sum up effectively and in comprehensible form. Mobile learning need more of these kinds of papers, specifying experience gained by reflecting on own and others research, and
the reasons that they were considered (partial) success stories or failures. This experience can be summarized informally as for example guidelines or lessons learned, or more formally as theoretical frameworks or models that can be used to support the development process.

This paper studies three mobile learning initiatives that the first author was involved in and formulates lessons learned from this experience. The lessons learned focus on things considered critical to the (lack of) sustainability of these three initiatives.

13.2 Related Work

The reflections provided in publications are important assets when trying to understand and learn from other mobile learning initiatives. These kinds of reflections are valuable but still sparse, and only a few attempts to share knowledge accumulated from longitudinal experiences in the field of mobile learning are visible.

Vavoula et al. (2004) offer a set of guidelines, i.e., a theory-informed and pedagogically sound set of do’s and don’ts, to direct different audiences of mobile learning, e.g., educational institutions, system designers, and teachers. These can be used as key considerations when starting a mobile learning initiative. So far, there are ten guidelines originating from their work of reviewing practice. The themes include costs, usability, choice of technology, roles, equipment management, support for teachers, administration, collaboration, services, and security vs. privacy. A justification for each guideline is provided in an elaborate discussion, followed by a clear reference to the specific initiatives it was extracted from.

From examining a number of mobile learning initiatives and describing the common features, Naismith and Corlett (2006) identified a set of critical success factors, i.e., availability of technology, institutional support, connectivity, integration, and ownership. These were corroborated by published results from the 2002–2005 mLearn proceedings. They further state that the literature is rich with complaints about the challenges facing mobile learning and hence provided helpful pointers to inform future initiatives.

Vavoula and Sharples (2009) propose that as the field of mobile learning matures and differences are noticed from example Technology-Enhanced Learning (TEL) and Mobile Human-Computer Interaction (mobileHCI), the next generation of frameworks and tools need to address the evolving aspects. They have been able to identify from their own experience six aspects that are expressed as challenges. These are to capture and analyze learning in context and across contexts, measuring mobile learning processes and outcomes, respecting learner/participant privacy, assessing mobile technology utility and usability, considering the wider organizational and socio-cultural context of learning, and address attributes of the environment in terms of formality and informality respectively.
13.3 The Three Mobile Learning Initiatives

In this section the three mobile learning initiatives are presented, which the first author of this paper had access to during the last years, via being a researcher at CeLeKT, Center for Learning and Knowledge Technologies at Växjö University, Växjö, Sweden, and a visiting researcher at COSC, the COnputer SCience Research Group at Canterbury University, Christchurch, New Zealand. Each initiative is briefly introduced with aim on describing the development process.

AMULETS (Kurti et al., 2008) is an initiative that explores how teachers can develop and implement novel educational scenarios that combines outdoors and indoors activities using mobile technologies combined with stationary desktops. Students are given a number of tasks to complete. The learning experience is centered on these tasks as well as the extra skills, for example collaboration and problem solving, needed to accomplish the tasks. The students use the mobile technologies to access information and interact with the environment using location i.e., positioning information or special codes, i.e., semacodes. They can also collaborate with other groups by sending instant messages and rich media. The devices allow the students to document the environment by taking photographs and record audio and video. The recorded data is automatically stored and tagged with location information so it can be displayed on interactive maps supported by the Google Maps application. This allows for the discussion and exploration to continue in the classroom and the data can also be used to support future outdoors tasks. AMULETS was divided into three trials that took place in 2006 and 2007. The initiative changed throughout the trials. The collaboration changed from between members within a team to between members within subgroups and between subgroups of a team. The activity changed from being serial both within a team and between teams to parallel between the two groups of a team and the different teams. Another change was how the individuals communicated. In the first trial, everyone could talk to everyone, while the second and third trial relied on messaging and recorded material.

The Podcast Initiative that took place at Canterbury University, Christchurch, New Zealand, aimed to utilize the inherent mobility of podcasts and provided supplementary material to a number of courses in various disciplines during 2006 and 2007 (Bell et al., 2007). Podcasting technology was used to supplement higher education, with audio-only material that students could use to refresh course work while doing other everyday activities such as household chores, commuting, and exercising. The involved students were offered supplementary podcasts with varying contents and format, for example 1-on-1 sound uptakes from lectures, interviews, and question-and-answer sessions. The evolution of the podcast initiative happened in three stages, with an increase in scope at each stage. At the time the initiative was initiated podcasting was a common phenomenon. The first stage investigated how known and accepted podcasting was within the student body.
as well as how many had access to portable digital audio players. Students were also asked if they would listen to educational podcasts and, if so, which format they would prefer. The second stage introduced supplementary podcasts for two first-year Computer Science courses. The two courses offered weekly podcasts. The third stage expanded the number of disciplines that used podcasts by including courses from Economics, Education, Japanese, and Music. The initiative also received funding from the university at this point. The format of the podcasts was similar to the previous stage, i.e., both lecture (1-to-1 sound uptake) and supplementary podcasts. The use of podcasts was evaluated throughout the initiative, primarily by questionnaires. The podcast initiative used a careful, feedback-driven process as it evolved between the stages. In each stage, feedback was gathered and this feedback was used to improve upon the current stage and to plan how to increase the scope while still taking the feedback into account. For example, the insight gained about the format of podcasts from stage two was preserved as a set of guidelines that were taken into account in stage three.

Skattjakt (Treasure Hunt in English) is a mobile game inspired by treasure hunt activities and orienteering (Spikol and Milrad, 2008). The initiative was originally conceived and developed to encourage young people to get physically active. The game is a mystery, driven by a strong narrative and the playing field is set across relevant locations. Students playing the game are divided into teams, and these compete against each other to finish first. Each team is given a map with locations and each location is a problem that needs to be solved in order to reveal the next location. An incorrect answer will result in a penalty, a detour, that will increase the time it takes for the team to complete the course. Playing the game involves map reading skills, problem solving, and learning tasks across different domains, and collaboration within the team. Each team is given a mobile phone that they use to play the game. The mobile phone displays an interactive map that players can zoom and pan out on. When a team encounters a specific destination they enter a code shown there, and the application running on the phone presents the problem they need to solve. The software provides audio clues, and the team gives an answer by choosing among a few alternatives to a question (correct or incorrect) that will reveal a new location on the interactive map that the team needs to find. The teams can also document their surroundings by taking photographs and recording audio and video. The recorded material will automatically be stored and tagged with location information. The route taken and the gathered material are presented on an interactive map that can be used for post activities after the mobile game is finished.

The evolution of Skattjakt can be divided into four stages. The control of the game content slowly shifted from the research group to the teachers and students over the four stages. Skattjakt has evolved from the product of collaboration between researchers and a local orienteering club to something that includes a complete authoring system, allowing anyone to create content. From an organizational point of view, it has evolved into some-
thing that can be integrated into an educational institution since content can be customized and made to suit particular needs and requirements.

13.4 Discussion of The Three Mobile Learning Initiatives

An analysis of the three initiatives described in Section 2 reveals a number of areas that influence the outcome. Several of these areas are shared between all three of the initiatives and these form considerations that might need to be handled during the development process. In this section the most important ones are addressed and discussed.

The technology can often be given the main focus of an initiative. There might even be a need to invent and develop new solutions to solve (technical) problems posed by the initiative. The three initiatives took different approaches to handle the technology.

The Podcast Initiative relied on existing commercially available solutions and pre-existing portable devices in use by the target group. Both AMULETS and Skattjakt used custom technical platforms that were developed as part of the initiative. The latter two also used mobile phones supplied by the research group. Connectivity is closely related to technology and if the learning relies on this, it has to be guaranteed. The Podcast Initiative faced the problem of students forgetting to download the material from the server, which in turn introduced a subscription model for automatic download when connection was present. In AMULETS and Skattjakt, the custom software provided other ways to work around lack of connectivity. For example, the game used in Skattjakt could work without connectivity. For AMULETS the running of several services on the mobile phones reduced the reliance on connectivity.

Many of the initiatives studied deal with large quantities of produced data that needs to be managed. For example, the number of available podcasts will grow quickly and the teams in AMULETS or Skattjakt produce many photos and recordings. All the initiatives had to manage the data. AMULETS and Skattjakt used systems to automatically tag the content with location information and everything was stored automatically at a server. The Podcast Initiative used syndication and aggregators to automatically push podcasts to the users' devices and to keep track of what was new or old, listened to or unheard. Podcasts were also categorized by discipline, course, year, date, and so on.

Scenarios and settings can be an effective way to support the learning. AMULETS used both the forest and a city square as a setting for the learning, while Skattjakt used various locations, for example a cottage where the poet and bishop Esaias Tegné (1782–1846) lived for a period, and a local castle where the former countess Anna Kostkull (1868–1917) returned as a ghost. If the scenario and settings are used correctly, it can provide a good way to support the learning, for example by supporting the problems
such as measuring the age and height of a tree.

However, if the scenarios do not make sense or do not work within the learning context they can have the opposite effect. For example, one of the Skattjakt trials used a game that provided power-up features that made no sense in the scenario, i.e., players had the ability to sabotage other teams, but since the teams were spread out, these features turned out to have little to no effect. The context of the learning, i.e., the environment within the mobile devices are used to learn in, is important.

The initiatives need to adapt to the context in order to better facilitate learning. For example, in AMULETS, the teams had to perform different activities, and the tasks and learning depended on whether it happened indoors or outdoors. The tasks also depended on locations, with specific tasks being performed at specific locations. Indoors, outdoors, and actual location are variables of the context. The Podcast Initiative supplied a variety of podcasts that were suitable for different contexts. For example, the 1-to-1 sound uptakes of lectures were suited for when students can read and take notes. Other formats were more suitable when the students were traveling or working out and did not have the time to listen to a complete lecture or deal with notes. Another context variable was the students’ language skills, and the opportunity for non-native English speakers to listen to lectures over and over.

Effective evaluation strategies can be hard to design. The three initiatives collected evaluation data but the strategy on how to utilize evaluation as method and the outcome differed. In AMULETS evaluation was conducted at the end of trials, using questionnaires to measure the students’ acceptance of the technology. In Skattjakt, evaluation data was continuously collected throughout the course of trials i.e., video, interviews, observation sheets, and questionnaires, which led to a magnitude of data to analyze. This was strenuous work and part of the solution presented itself by applying co-design, as feedback and change to the initiative is inherent to this process. The Podcast Initiative relied on survey data, based mostly on questionnaires but also inherent to the action research approach applied, observations and interviews are part of the evaluation method.

Any mobile learning initiative has a number of stakeholders, persons or groups that will be affected by it directly or indirectly. Barker et al. (2005) identified the following stakeholders: the students, the teaching staff, the system designers and engineers, device vendors, and the educational institution representatives. The initiatives studied take different approaches to stakeholders and requirements. Skattjakt uses a very inclusive process, where some of the stakeholders take the role of co-designers, while the Podcast Initiative used a close feedback loop with constant check-points to see if the requirements are met and do the necessary changes accordingly. AMULETS handled stakeholder groups in turn, locked down the requirements before continuing with the initiative and the next round.
13.5 Sharing Experience by Lessons Learned

As previously mentioned, the experience and hence knowledge extracted from prior initiatives can be used in several different ways. For example, by informing other researchers, these can gain an advantage and not “start from scratch” when undertaking a new initiative in mobile learning. This understanding can be presented in form of new theoretical contributions i.e., the initiatives presented in this paper and the experience from them has been used to create a theoretical framework to aid the development process of new mobile learning initiatives, as described by Wingkvist (2008). Another means to transfer the knowledge gained is to produce lessons learned, which can also be used to inform other researchers. The rest of this section studies how the experience from past initiatives can be crystallized into overarching lessons learned.

Technical development takes a lot of time and resources. Consider the implications of technological development, since it alone should not be the goal of a mobile learning initiative. In the development of a new initiative we would recommend to use pre-existing technology or to cooperate with partners who already have a “technical platform”. Using technology available commercially off the shelf can further reduce the time and resource. By using already existing technology, the focus can be put on using it rather than developing, which fits the idea of making technology the tool, not the focal point.

It is not reasonable to expect that all learning activities can happen while connected. Be aware of connectivity, or implicitly how to function without it if necessary. There are several mechanisms to allow an “offline mode”. Data, such as podcasts, can be downloaded to the device ahead of time using subscription models. In more advanced scenarios, applications can run on the local devices, and any data captures (audio, video) can be stored locally and uploaded when there is a connection. Similarly, the various devices can communicate among each other using ad hoc networks, or use synchronization to put the data together.

Data management can be an important consideration. A mobile learning initiative might produce large amounts of data, for example podcasts, photos, and videos, and all of this data should be tagged using semantic markups, for example location and time. This markup is important for several reasons, e.g., it allows the data to be categorized and viewed in a number of different ways, for example in iTunes or using digital maps. This can later be used in post-activities. Similarly, the semantic markup will allow for the various synchronizations. Semantic markup and various social network sites and concepts will allow the students to share the material among each other as well.

The basic idea of a mobile learning initiative is to “learn by doing”, and this can be enforced by sound scenarios, i.e., students study the surrounding environment with a focus on for example forest ecology and history. This includes disciplines such as biology, geography, and mathematics, and can
be carried out in almost any environment with surrounding nature. The scenario should make a good job of tying the location, the learning experience, and the tasks together that simply “makes sense”. As part of the scenarios, the learning experience will take place across physical locations, and often include indoors and outdoors activities. For example, the learning experience might consist of indoors activities, outdoors activities and briefings, and follow-ups indoors. Sensor readings and semantic tagging such as time and location can be used to track this information, and provide a “context” to the learning activity when reviewed during post-activities.

The results of the evaluation of a mobile learning initiative are what can and will be “judged” by others. It is important to consider the evaluation and the strategies used in order to make sure that the desired qualities can be produced. It is important to evaluate the efforts in a thorough way, and the evaluation methods should be designed before the initiative begins. Continuous evaluation should be designed and planned and the initiative should adapt accordingly to the outcome of it. A flexible stance is desired and the feedback should be used to directly affect the further development of the initiative.

Be aware of stakeholders, as a mobile learning initiative has more stakeholders than the obvious teachers and students, even though these can be seen as the most important. The success and survival is depending on more stakeholders and identification of these is crucial. All groups of stakeholders should be considered. To be able to transfer the initiative to the care of the organization it is intended for, a plan for this needs to be in place specifying the conditions. Dialogue with for example the principal and the university board early on is very important. One way to include the stakeholders is co-design of for example learning activities. This allows teachers and students to better integrate the technology and the learning with classroom activities. Co-design can for example be supported by workshops with stakeholders, researchers, and domain experts (with specific knowledge of the intended scenarios).

13.6 Conclusions

This paper presents three initiatives in mobile learning with focus on the experience gained during the development process of these initiatives. In summary the lessons learned revolves around the basis of technology, spanning over connectivity aspects, and data management arrangements, continuing with scenario building, choice and design of evaluation method, and cooperation with stakeholders. These types of presentations of reflections are valuable for researchers to bear in mind when developing new initiatives.

Reflections and lessons learned are inherently work in progress, and will be continuously explored. Another future effort could be to investigate how lessons learned are used to transfer experiences between researchers. This includes how to present them, as well as how experience from different re-
searchers can be systematized and merged giving an invaluable contribution to support the development process of new initiatives in mobile learning.

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Publication VIII

Current Practice in Mobile Learning: A Survey of Research Method and Purpose

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Abstract

In this paper we present a survey of published research in mobile learning. We investigated 76 papers from mLearn 2007 and 2008, and classified them according to two dimensions: research method and research purpose. Research methods and purposes are important parts of how research is conducted. Alas, opinions and approaches towards research differ greatly. The classified papers are evenly distributed among the research methods investigated, with one exception, being few in Basic research. In terms of research purpose, papers aimed to describe were well represented while there was a lack of papers targeting evaluation. Papers recounting both Basic research and research done to evaluate are imperative since they help a research field to mature and also help researchers to avoid repeating known pitfalls. This maturity, in turn, will lead to better scalability and sustainability for future research efforts in the community of mobile learning.

Keywords: method, mobile learning, purpose, review, survey

14.1 Introduction

Naismith et al. (2004) defines mobile learning as mobile technology that supports learning across locations, or learning that takes advantage of the opportunities offered by portable technologies. There has been a rapid growth in research, development, and deployment of mobile learning in recent years (Taylor et al., 2006). This rapid growth has led to a number of significant activities in schools, workplaces, museums, cities, and rural areas around the world according to Kukulska-Hulme et al. (2009). There is however a number of identified issues that need further attention (Sharples et al., 2008). The research conducted in mobile learning is often small scale and seldom developed into learning aids that are in wide use; hence we are faced with both limited scale and sustainability (Keegan, 2005). The field is compelled to evolve and find common ground in order to develop comprehensive principles and realistic visions, moving beyond specific implementations and branded technologies (Cobcroft et al., 2005). Traxler and Kukulska-Hulme (2005) conclude that only few of the studies have been based on sound theory.

Mobile learning is still considered a young research field. The first research publications appeared in the late 1990s and the first international conference was held in 2001, called the World Conference on Mobile Learning, and in short mLearn. Vavoula and Sharples (2009) state that many of the influences, and in turn frameworks, methods, and tools have been borrowed from other research fields, such as Technology-Enhanced Learning and Mobile Human-Computer Interaction. Influences from research fields such as Computer Supported Collaborative Work and E-learning can also...
be seen. Many researchers active in the field of mobile learning have backgrounds in Computer Science, Educational Studies, Information Systems, and Media Technology. The body of researchers includes both academics and professionals (e.g., educators and software developers.)

A young research field is often highly opportunistic and technology driven. A primary focus is set on producing solutions and less attention is given to research methods and the execution of the scientific process. As mobile learning matures it is necessary to examine how this line of research is being conducted. At the same time we need to understand the impact of the technology and comprehend the knowledge that is produced. This introduces challenges to all aspects of mobile learning research. Vavoula and Sharples (2009) state that as the understanding of mobile learning deepens, the "borrowed" frameworks, methods, and tools might no longer be adequate and need to be processed and evolved. They in turn propose a framework build on holistic and systematic evaluation divided in three levels of granularity (micro, meso, and macro) to guide the data collection. Vavoula and Sharples (2009) also noticed that mixed methods are increasingly present in the design of evaluation for mobile learning. This can also be seen in terms of how the entire research process is conducted. Realizing and consciously being aware of the spectrum of research methods will, in the long term, allow us to influence the future direction of the research done in the field of mobile learning.

Emphasis on research methods and research purposes is important as these decide how research results are used and interpreted. Methods and purposes are also important because they help a research community to be built and allow this community to formally share results, and being an outlet for knowledge transfer. For instance, Traxler (2007) specifies that the significant challenges for research in mobile learning lies in scalability and sustainability, and therefore frameworks, methods, and tools need to respond to these challenges. Hence, it is necessary to have a thorough understanding of the fit between the approach chosen and the goal of the research. Wingkvist and Ericsson (2009) suggest careful scaling according to pre-set specifications to increase the sustainability of research initiatives in mobile learning.

Discussing research methods and purposes is an integral and intricate part of scientific conduct. Initiators of this discussion were Wynekoop and Conger (1990), followed by Kjeldskov and Graham (2003), and later Jensen and Skov (2005). The classification schema presented within these papers demonstrates an usable and straightforward approach to enhance the discussion of research methods. In order to survey methods and purposes, the World Conference on Mobile Learning (mLearn) was selected as a prime subject for the appreciated publications accredited to mobile learning. The mLearn conference represents current practice conducted within mobile learning and highlights how research is carried out.

The rest of the paper is organized as follows, having this introduction followed by a presentation of eight well-established research methods and four
research purposes. These provide the two dimensions of our survey, allowing
us to review and discuss the results. We then present the classification and
an interpretation of the results, and ending the paper with conclusions.

14.2 Research Methods

In this section we present the eight research methods, including their weak-
nesses, strengths, and primary use in mobile learning research. The research
methods are extracted from Wynekoop and Conger (1990) with supplementary
input from references on research methods prominent in Information
Systems (due to first author’s background and main area of expertise). The
methods considered are Case studies, Field studies, Action research, Ex-
periment studies, Survey research, Applied research, Basic research, and
Normative research. Research methods often overlap, so we emphasize the
defining characteristics of each of the methods to show the classification of
existing papers.

The eight research methods are environment dependent, artificial, or en-
vironment independent (Benbasat, 1985). The first three methods, Case
studies, Field studies, and Action research are used in a natural (real) set-
ting and are environment dependent, while Experiments are carried out in
a somewhat artificial setting. The remaining four (Survey, Applied, Basic,
and Normative research) are all environment independent (but not artifi-
cial). This categorization of the eight methods is summarized in Table 14.1.

Case Studies

Case Studies according to Yin (2003) are an example of an empirical enquiry
that investigates a contemporary phenomenon within its real life context,
especially when the boundaries between phenomenon and context are not
evident. In respect of the researcher the boundary from the phenomena
is distinct as the researcher is a passive and independent outsider. Case
studies are often intensive evaluations of small size entities such as groups,
organizations, individuals, systems, or tools.

In general the data is collected by a combination of qualitative and quan-
titative methods such as observations, interviews, and questionnaires, with
limited experimental or statistical control imposed. This often results in a
complicated analysis, as the data collected in a natural setting is by default
very rich and sometimes conflicting or incoherent. Case studies are on the
other hand particularly well suited for research focusing on describing and
explaining a specific phenomenon and for developing hypothesis or theory.
However, case studies can be very time demanding and the findings hard to
generalize upon. In mobile learning, case studies could be used to provide
rich data explaining phenomena involving the use of mobile devices in a
specific context.
<table>
<thead>
<tr>
<th>Method</th>
<th>Strengths</th>
<th>Weaknesses</th>
<th>Use</th>
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<tbody>
<tr>
<td>Environment dependent setting</td>
<td>Case studies</td>
<td>Process understanding</td>
<td>Costly, time demanding</td>
</tr>
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<td></td>
<td>Demonstrate causality</td>
<td>Limited generalizability</td>
<td>Explanations</td>
</tr>
<tr>
<td></td>
<td>Natural setting</td>
<td>No experimental control</td>
<td>General hypothesis</td>
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<td>Rich data</td>
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<tr>
<td>Field studies</td>
<td>Natural setting</td>
<td>Difficult data collection</td>
<td>Studying current practice</td>
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<td></td>
<td>Independent variables manipulation</td>
<td>Unknown sample bias</td>
<td>Evaluating new practice</td>
</tr>
<tr>
<td></td>
<td>Replicable</td>
<td>No experimental control</td>
<td>Post hoc study of processes and outcomes in practice</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No guarantee of independent variable variation</td>
<td>Generating Hypothesis</td>
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<tr>
<td>Action research</td>
<td>First hand experience</td>
<td>Ethics consideration</td>
<td>Generating hypothesis/theory</td>
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<td></td>
<td>Applying theory to practice</td>
<td>Researcher bias</td>
<td>Testing theories/hypothesis</td>
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<td></td>
<td>Close relationship with subjects</td>
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<td>Unknown generalizability</td>
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<tr>
<td>Artificial setting</td>
<td>Experiment studies</td>
<td>Control of variables</td>
<td>Limited realism</td>
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<tr>
<td></td>
<td></td>
<td>Replicable</td>
<td>Unknown generalizability</td>
</tr>
<tr>
<td>Environment independent setting</td>
<td>Survey research</td>
<td>Relatively easy, low cost</td>
<td>Collecting data from large samples</td>
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<td></td>
<td>Context insensitive</td>
<td>Providing statistic picture</td>
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<td></td>
<td></td>
<td>Can reduce sample bias</td>
<td>Developing hypothesis</td>
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<td></td>
<td></td>
<td>No variable manipulation</td>
<td>Testing relationships between factors</td>
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<td></td>
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<td></td>
<td>Descriptive data collection</td>
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<tr>
<td>Applied research</td>
<td>The goal is a product which may be evaluated</td>
<td>Solution constrained</td>
<td>Product development</td>
</tr>
<tr>
<td></td>
<td></td>
<td>May need further design to make product general</td>
<td>Goal-oriented hypothesis testing</td>
</tr>
<tr>
<td>Basic research</td>
<td>No restrictions on solutions</td>
<td>Costly, time demanding</td>
<td>Building theory</td>
</tr>
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<td></td>
<td>Solve new problems</td>
<td>May produce no solution</td>
<td>Solving new problems</td>
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<td></td>
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<td>Solution may not match known problems</td>
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<td>Normative research</td>
<td>Insight into firsthand experience</td>
<td>Opinions may influence outcome</td>
<td>Descriptions of practice</td>
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<tr>
<td></td>
<td>Basis for other forms of research</td>
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<td>Building frameworks</td>
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</tbody>
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Table 14.1: Summary of Research Methods (adapted from Wynekoop and Conger (1990))
Field studies

Field studies are characterized by taking place in a natural setting, allowing the researcher a flexible stance in respect to variables, the degree of and manipulation of the same. However, as control increases over variables the pragmatism decreases. Using a range of qualitative and quantitative approaches, data is collected often through observations and interviews, supporting the study of complex situated interactions and processes as addressed by Klein and Myers (1999). The phenomena are placed in a social and cultural context. The advantage is the corpus of data, realistically extracted, and in relatively short time period. The disadvantages are unknown biases, extensive data collection, and having no guarantee that the data is representative. In relation to mobile learning, field studies could be applied in current practice for either informing design or understanding the mobility of users, evaluating design or theory by conducting research in a realistic setting.

Action research

Action research is particularly suited to application in an actual and natural setting; that is to study social and cultural phenomena. According to Baskerville and Myers (2004) the researcher actively participates in solving a problem while at the same time evaluating the results and making a knowledge contribution at large. For example, it allows the introduction, transformation, evaluation, and extraction of theories.

The advantage of being so engaged in the activity facilitates first-hand understanding and supports the learning process for all those involved. However, the disadvantage is that it can be very time consuming, and since the researcher takes part in the phenomena studied, remaining at a critical stance can be hard. Even though the outcome is attached uniquely to the research conducted, it does offer a degree of external validity since others can interpret the theoretical contribution made. Nevertheless it can still be difficult to generalize upon. In relation to mobile learning, action research provides the perfect opportunity for a researcher to jointly collaborate with the “team”.

Experiment Studies

Experiment Studies are characterized by the researcher’s ability to control dependent variables often by creating an artificial setting or situation. Being able to do this is prohibitively difficult or even impossible and a researcher often resorts to quasi-experiment studies as presented by Denscombe (1998). These usually take place in uncontrolled environments, variables from undetected sources are neither measured nor held constant, and these may produce misleading correlations between variables under study. Data can be collected depending on the style of the subsequent analysis desired.

The major advantages of experiment studies are the opportunity to focus on specific phenomena of interest and a large degree of control in terms of manipulation of variables before and during the study through for example
assignment of test subjects and exposure to different treatment variables. Also, well designed and executed experiment studies are highly replicable and facilitate data collection. Disadvantages include limited connection to the real world and an unknown level of generalizability of the results outside of the specific setting. In mobile learning research, experiment studies are suitable for evaluating design ideas, specific products, or theories about design and user interaction in controlled environments with little or no interference from the outside world.

**Survey research**

Survey research provides information from a defined population and the data, which is gathered directly through, e.g., interviews, publications, and questionnaires, is assumed to be independent to the environment as stated by Fowler (2002). In essence, data from survey research is collected without the researcher’s intervention or stake other than the gathering of data. Data is most often analyzed quantitatively, but data from interview surveys can also be analyzed qualitatively.

The advantages are that they facilitate large amounts of data to be gathered with relatively little effort, supporting broad generalization of results. Also a high level of control regarding sample subjects makes reduction of bias possible thus increasing validity. However, a disadvantage is that it suffers from providing only snapshots of studied phenomena and relies heavily on the subjective views of respondents. In respect to mobile learning, survey research could, for example, facilitate general information being gathered about user needs and requirements, or of a phenomenon, and from this develop an understanding of the current situation.

**Applied Research**

Applied Research is similar to prototyping and based on a trial-and-error practice relying on the expertise and reasoning of the researcher’s capabilities through intuition, experience, deduction, and induction. The outcome is known in terms of requirements, but not the method of obtaining the same as mentioned by Järvinen (2004). In line with this goal orientation, the advantage is that some kind of result being produced, and can be evaluated against the pre-set goal. The disadvantages are that the initial goal may be very limited and not generalizable, and that appropriate solutions for accomplishing the desired outcome may not be produced at all. Applied research is relevant for mobile learning in relation to design and implementation of systems, interfaces and techniques, which meet certain requirements for performance, user interaction, user satisfaction, etc.

**Basic Research**

Basic research allows the researcher to study well-known problems to which methods or possible solutions are yet to be identified. The aim is to find out what is part of reality and often the researcher is concerned with the
development of a new theory (Järvinen, 2004). The approach is also trial-and-error based, riding on the competence of the researcher. The advantage is the directness of the research that is facilitated by the open choice of approaches and time, allowing a high level of creativity in the search for methods. The down side is that it can be very time consuming and there is no guarantee that a solution will eventually be produced. In relation to mobile learning, basic research may be applied to the development of theoretical frameworks for understanding fundamental principles, for example issues related to mobility or for identifying new problems related to learning while users are on the move.

Normative Research

Normative research is less rigorous in terms of research method per se though usually address interesting phenomena from a pragmatic standpoint. This is done in order to stimulate and indicate directions for future research, and for example covers writings of application descriptions, idea, concept, and suggestion development (Tolvanen et al., 1996). The narratives often seem intuitively correct but are not based on theory or research rigorously conducted, and are presented according to the style of a practitioner, i.e., giving a subjective view and focus on what worked in that particular situation.

The advantage is that this kind of writing is more straightforward and often perceived easier to produce compared to presenting complex theoretical contributions. Drawbacks consist of limited theoretical foundation, weak methodological reflection, and low generalizability. However, the ones that reach the stage of publication often provide well-prepared arguments with considerable backing from other sources. For mobile learning, the papers describing general statements or designs, and procedures that worked well or did not prove successful, are representative.

14.3 Research Purposes

In this section the research purpose is defined as the second dimension of the survey. The purpose of a research effort is closely linked to the research method used and vice versa, so these two notions make an excellent pair when attempting to classify mobile learning papers. The definitions of the four research purposes are inspired by Wynekoop and Conger (1990), although a slight refinement was made. The original categories were: Understanding/Describing, Engineering, Re-engineering, and Evaluating. We divided Understanding/Describing into two categories and merged Engineering and Re-engineering into one category called Developing. These changes were done first to differentiate between Understanding and Describing in order to sharpen the categorization in respect of each other, and secondly to merge the other two because mobile learning application and framework have not been around long enough to fully use the categoriza-
tion of re-engineering. In lieu of this the categories for research purposes are: Describing, Developing, Understanding, and Evaluating. These four research purposes are explained and defined here:

**Describing** refers to writings that describe the unit under study, such as features of the portrayed environment, the technical implementation, often represented in models of low level of abstraction. Describing papers provide knowledge about the research in a straightforward manor with emphasis on actual results.

**Developing** refers to writings that define frameworks, be it technical or theoretical, and emphasis on development and the presentation of solutions. A typical example is when the aim is to develop a new conceptual model or a prototype, i.e., papers that basically provide first hand knowledge in uncharted territory.

**Understanding** refers to writings that seek to understand and make sense of conducted research, while trying to bridge the result into a theoretical frame, often present new constructs based on identifying and enhancing theory. Understanding papers provide knowledge of a wider theoretical setting, often found in research that is in the process of rethinking something.

**Evaluating** refers to writings that evaluate the usefulness, benefits and shortcomings of the research, while hopefully giving pointers to other researchers. These papers can be seen as evaluating methods and purposes in practice and reflecting upon these, i.e., provide knowledge about lessons learned, which can give a head start or at least the possibility to avoid pitfalls.

These four categories of purpose along with the methods are used in the next section as a basis for classifying mobile learning research papers from two World Conferences on Mobile Learning, mLearn 2007 and mLearn 2008.

### 14.4 Classification of Mobile Learning Research

The proceedings of mLearn 2007 (Norman and Pearce, 2007) and mLearn 2008 (Traxler et al., 2008) were selected to get a picture of current practice in mobile learning. Traxler (2007) proclaims that the mobile learning community is currently visible mainly through dedicated international conference series, of which mLearn is the most prestigious, rather than through
any journals. The mLearn conference series is renowned for including contributions from academics as well as practitioners. All the 76 full papers from mLearn 2007 and 2008 were classified. The papers are numbered in the order they are printed in the conference proceedings with the first paper from mLearn 2007 as paper #1 and the first paper from mLearn 2008 as paper #39 (cf. Appendix). The data set as defined by Robson (2002) is the set of papers from mLearn 2007 and mLearn 2008, which provides a solid and adequately representative basis for this survey. Each paper was peer reviewed, which indicated that the published papers are of good quality and of importance to the community. 76 such papers is a relevant and sufficiently large sample to draw conclusions from.

Initially the first author reviewed all papers. Each paper was thoroughly read with particular focus on identifying the purpose of the presented research as well as the method applied to accomplish the research. Many papers can be classified as having a number of purposes or methods, but the most coherent and dominant from each category were selected to classify the paper according to the two dimensions, respectively. Moreover, an international master’s student repeated the same classification process. The results of the two classifications were compared and a final decision was made for each paper. This decision was then discussed and collaborated by the second author, who now also read all the papers. The complete survey result of the 76 papers is presented in Table 14.2, including the total share of each category in percentage.

Table 14.2 shows that the most commonly used method within mobile learning research is Case studies, with 24% (18 out of 76) of the papers. The second most used method is Normative research, which 21% or 16 out of 76 papers used. Applied research and Survey research are also commonly used; the former was used by 17% of the papers while the latter was used by 14%. Of the less generally used methods, Field studies and Experiment studies are more common, with 9%, and 8% respectively, while Action research was used by 5% of the papers. Only one paper was classified as Basic research. The classification shows that environmental independent research (Survey, Basic, Applied, and Normative research) dominates and was used by 54% of the papers. 38% use environment dependent methods (Case studies, Field studies, and Action research) and focus on studying real use in a natural setting. 8% of the papers use an artificial setting (Experiment studies). In environmental independent research, Normative research was the most common method, closely followed by Applied research (39% respectively 31%). Case study dominated the environment dependent methods and was used by 62% of the papers. By definition, 100% of the artificial research used Experiment research.
<table>
<thead>
<tr>
<th></th>
<th>Case studies</th>
<th>Field studies</th>
<th>Action research</th>
<th>Experiment studies</th>
<th>Survey research</th>
<th>Basic research</th>
<th>Applied research</th>
<th>Normative research</th>
<th>Total (in %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Describing</td>
<td>1, 3, 6, 11, 22, 29, 32, 37, 40, 45, 50, 66, 70</td>
<td>2, 12, 28, 39, 59</td>
<td>49, 54, 71</td>
<td>16, 17, 27, 31, 73</td>
<td>8, 38, 41, 53, 76</td>
<td>5, 15, 24, 34, 56</td>
<td>4, 9, 19, 23, 25, 33</td>
<td></td>
<td>55.26%</td>
</tr>
<tr>
<td>Developing</td>
<td>10</td>
<td>57</td>
<td>13</td>
<td>69</td>
<td>7, 20, 21, 26, 36, 46, 60</td>
<td>14, 18, 43, 44, 51, 52, 68</td>
<td></td>
<td></td>
<td>23.68%</td>
</tr>
<tr>
<td>Understanding</td>
<td>55, 58, 67, 74</td>
<td>47</td>
<td>64</td>
<td>42, 48, 63, 65, 35</td>
<td>72, 75</td>
<td></td>
<td></td>
<td></td>
<td>17.11%</td>
</tr>
<tr>
<td>Evaluating</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>62</td>
<td>30</td>
<td>61</td>
<td></td>
<td>3.95%</td>
</tr>
<tr>
<td>Total (in %)</td>
<td>23.68%</td>
<td>9.21%</td>
<td>5.26%</td>
<td>7.89%</td>
<td>14.47%</td>
<td>1.32%</td>
<td>17.11%</td>
<td>21.05%</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

Table 14.2: Classification of Mobile Learning Research Papers.
In Figure 14.1 the papers are first divided by environment and secondly by method to show the number and percentage that cover each category. The most common purpose of the research was to describe the study (Describing), with 55% (42 of 76). This was followed by Developing and Understanding, 24% (18 of 76) and 17% (13 of 76), respectively. Only 4% (3 of 76) of the papers had Evaluating as their research purpose. Research with the purpose of Describing most commonly used Case study as the research method. This was used by 31% of the Describing papers. The rest of the Describing papers were almost equally distributed among Experiment, Survey, Applied, and Normative research (12% for the first three, 14% for the last), while 7% of the papers used Action research. The papers with a purpose of Developing usually used Applied or Normative research, and 78% (39% each) of all the Developing papers used either of those two methods. The remaining 22% were equally divided between Case study, Field study, Experiment study, and Survey research. The Understanding papers were most commonly either Case studies or Survey research (31% each). The remaining papers used Field studies, Action research, or Basic research (8% each). The three Evaluating papers were divided into using Survey research, Applied research, or Normative research.

The Case study research method was most commonly used for the Describing purpose. 72% of the Case study papers fall within this purpose. Similar results hold for Field studies, Action research, and Experiment studies, where 71%, 75%, and 83% of the use of these methods is done with the purpose of Describing. The remaining methods, apart from Basic Research, are generally used for two purposes, e.g., Survey research is most commonly done either for Describing or Understanding, with 45% and 36% respectively.

Within mobile learning there is a tendency towards research in an independent environment aiming at Describing and Developing. In the environmental dependent category Case study dominates with 62% (18 papers) and for all the 29 papers in that whole category, 21 papers have the purpose of Describing. Understanding (and presenting theoretical framework) is the focus of 13 papers (17%), which limits the body of knowledge for mobile
learning. Of the 13 papers of Applied research, 93% do so for the purpose of Developing and Understanding. Of the 6 papers in the Experiment category, 83% (5 papers) use this method for Describing purposes. Of the 7 papers that report Field studies, 5 papers use this method for Describing purpose, while 2 papers use it for a Developing and Understanding purpose, respectively. Applied and Normative research is most commonly used for Describing or Developing. In the case of Applied research, 38% of the papers utilizing this method are Describing, while 54% are Developing. In the case of Normative research, 38% are Describing, while 44% are Developing. The sole paper that used Basic research used it for Understanding.

14.5 Discussion

This section presents an analysis of the results of the classification presented in the previous section. Generally, the research conducted is either close to one situation in particular, gathering empirical data, or on a normative level presenting ways to utilize the essence of mobile learning in an abstract sense. These two represent opposite ends of the spectrum given method choice and purpose and out of the 76 papers considered in this survey, 51 papers fall into either of these (67%). This proves the need for a broader scope in terms of methods and purposes to help the research field to mature and also help researchers to avoid repeating known pitfalls. This maturity, in turn, will lead to better scalability and sustainability for future research efforts in the community of mobile learning.

Mobile learning is evidently an interdisciplinary field with ties to for example Computer Science, something that might explain the emphasis on Applied research and data gathering. Methods used in related fields, e.g., Information Systems and Software Engineering are also noticeable within mobile learning, for instance with Action research, Case studies, and Field studies. A difference compared to these related disciplines, however, is the lack of artificial environments and Experiment studies found in this review of the papers. From the 76 papers, only 6 presented some kind of Experiment studies. In some of the related fields, experiments are more common, for example Kjeldskov and Graham (2003) show that Experiment studies is the second most common research method used in Mobile Human-Computer Interaction. This divergence may be a result of the difficulty to emulate aspects of mobile learning, such as mobility and the dynamics of context changes in an experimental setup. Field study, on the other hand, offers an ideal opportunity for the study of rich real-world cases. Mobile learning is applicable and well understood in a natural and environment dependent setting. The use of research methods such as Case study and Action research aids and strengthens the result when studies are conducted. Mobile learning researchers could learn from other disciplines that have struggled with the study of similar phenomena often depending on the degree of involvement from the researcher. Experimental studies and the use of control
groups are subsequently essential.

The prevalence to gather empirical data and the research that is conducted to describe a phenomenon shows a strong connection to real-world cases. Much of the research conducted is done to describe how the real world works and is often presented as the result of a small-scale study where a population used mobile learning technology. This data is presented, not interpreted, and offered as a description of the process. On the other end of the spectrum there is the normative research that is also done with the purpose to describe and develop. Many of the papers that fall into this category present either a description of a current situation or a future situation describing what may happen or how something should be developed. These papers are based on some evidence and are generally visionary. Between these two, Basic research, and Evaluating research is expected, but not found. Out of the papers reviewed, 4 fall into either of these categories, none in both.

There is a distinct lack of Evaluating and Basic research among the papers reviewed. The one paper we found in Basic research is mirrored in the survey of Jensen and Skov (2005) that also only found one such paper in relation to their field (Children’s Technology Design). Many of the papers include an attempt at reflection. This is often not the purpose and almost always leads to the evaluation from an end-user perspective. There is little reflection by revisiting results, or evaluation of the effort compared to other efforts. This is a problem. In a similar manner, much of the research is done to describe, not understand or evaluate. This may indicate a lack of maturity, a lack of a clear definition of the field. There is still a need to describe how it works in order to define it. There is a need to bridge the gap between descriptive small- scale research and normative visionary research, by evaluating and trying to understand. This is where the knowledge is produced and theories are formed.

One reason for the lack of Evaluating and Basic research might be the speed in which mobile technologies are developed and improved upon. A generation of mobile devices is short-lived, which may result in many technical aspects being lost when a new generation is introduced or many studies feeling outdated and old, which in turn may affect evaluations and reflections. This lends well to simply stating facts or presenting visionary plans. However, without proper focus on the research process, including methods and purposes, it is hard for research in mobile learning to transfer already obtained knowledge into the starting point for new efforts.

One way to describe the papers reviewed is to consider some of them as standing on the frontiers looking into the future and others working hard to keep up with the development. A challenge for mobile learning research would be to stop, turn around, and reflect over the results once again. This is the way to reach the visionary future, which is predicted by looking ahead avoiding already known pitfalls. Also, a head start is given if research is built upon previous research instead if the wheel is reinvented every time a new mobile learning initiative gets on its way.
Given this review it must be stated that research methods and a classification of research according to defined methods is not an exact science. Some definitions can be considered vague or even overlapping with other methods. To make issues even more complicated, few papers contain a discussion of the exact methods used, so in many cases it is up to judgment calls. With the overlapping and vague methods it was sometimes hard to pick one, and only one, method. For example, is a study conducted in a natural setting but with all variables fixed a Field study or an Experiment?

Further along these lines, it should be acknowledged that the survey presented in this paper has some limitations. It can for example be discussed if the research papers presented at a conference although marketed central to the field is really representative of the research and activities that are conducted within the field. Furthermore, it is not always easy to compress the research to fit the page limitations or topics of interest at a conference. The conference series selected for this review provides papers from a wide range of researchers and research projects. The authors read each paper several times, and carefully discussed the method and the purpose before it was classified. However, the purposes and methods matrix, as classification tool, has been used for a number of similar publications. Further, the results of the classification in this paper show a clear trend that is difficult to attribute to vague method definitions. Based on these observations, the authors of this paper are confident that the research conducted is of value, even with the limitations placed on it.

### 14.6 Conclusions

Research methods and research purposes are an integral and intricate part of how people conduct research. In this paper we presented a two dimensional matrix where we compared research methods and research purposes in a selection of 76 papers. The first dimension consists of eight research methods: Case study, Field study, Action research, Experiment, Survey, Applied research, Basic research, and Normative research. The second dimension consists of four research purposes: Describing, Developing, Understanding, and Evaluating. The 76 papers we investigated represent a broad selection within current practices in mobile learning.

Our classification shows an even distribution in respect to research methods, with only Basic research being under-represented. In terms of research purposes, Describing is the most frequent used within more than half of the papers, followed by one-fourth of Developing papers, and one-fifth Understanding. Evaluating, on the other hand, is represented only within about one-twentieth of the total amount of papers we have investigated. Our survey reveals that there is a clear lack of Basic research and Evaluating papers. This obviously indicates a void that could be filled with publications specifying lessons that were learned, describing benefits as well as shortcoming of research already conducted.
In a young and evolving research field it is necessary to try new research methods, which in turn can greatly improve the diversity of the research published. Mobile learning is an excellent example of an evolving field where researchers apply various methods and practices to solve their problems. Our survey shows exactly that and our findings further present a number of opportunities for future research. We suggest that researchers revisit and evaluate their research methods. This can lead to evolution and presentation of new frameworks, methods, and tools. This holistic approach and systematical description is important not only for method and purpose in research but also for improving the overall system development process that mobile learning research is faced with.

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APPENDIX — FULL PAPERS

mLearn 2007

1. Ally, M. et al., *Use of Mobile Learning Technology to Train ESL Adults*
2. Arrigo, M. et al., *A Collaborative Mlearning Environment*
5. Cochrane, T., *Moving Mobile Mainstream: Using Communities of Practice to Develop Educational Technology Literacy in Tertiary Academics*
6. Cooney G. & Keogh, K., *Use of Mobile Phones for Language Learning and Assessment for Learning, A Pilot Project*
7. Elson, B. et al., *Blueprint for an Adaptive Training - Virtual Learning Environment (Adapt-VLE) for the Training of Dentists*
8. Goerke, V. & Oliver, B., *Defining the Handheld Computer for a First Year University Student: Is it a 'Handy' Accessory or an Essential Learning Tool?*
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18. Mann, S and Reimann, P., *Mobile Technology as a Mediating Tool for Learning in the Convergences from Technology, Collaboration and Curriculum Perspectives*


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25. Kress, G. & Pachler, N., *Thinking About the 'M-' in Mobile Learning*


27. Petrova, K., *Student Revising for a Test using SMS*

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