EXPLORING OPPORTUNISTIC USE OF MOBILE DEVICES FOR STUDYING IN HIGHER EDUCATION

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Abstract

Students today often feel that they have too much to do and too little time. A common strategy to remedy this is to take advantage of opportunities to use “inter-time”, the time between other activities such as waiting or traveling. The aim of this thesis is to explore how studying using mobile devices in higher education can be designed for such opportunities. I choose to call this Opportunistic Mobile Studying (OMS).

Using a design-based research approach this thesis discusses and proposes both scientific and practical contributions. A number of iterations of OMS have been designed, instantiated and tested in university courses and then evaluated using mixed methods.

The first research question is how can OMS be designed to support students in adopting the behavior of studying at opportune moments. The results have been framed and interpreted using the Fogg Behavior Model, where behavior is the product of motivation, simplicity, and triggers. The results suggest that a key factor for motivation is procrastination, and therefore deadlines can be used to predict and suggest what students would likely be interested in studying during OMS moments. Simplicity is increased if OMS is adapted for studying in short fragmented moments, where important aspects are that content should be short, easy to access and easy to navigate. Trigger reminders were particularly appreciated and should be triggered based on time and place. Commuting is identified as a good context to build a routine of studying using OMS.

The second research question is how can OMS activities and content be designed to support efficient studying in OMS situations. Study-activities identified as especially suitable for OMS situations are those that focus on preparation and repetition. These activities can enhance other learning activities and efficient studying can be accomplished even if only a little time is available. Examples of successful methods for this tested in this thesis include advance organizers and flashcards. Longer and more comprehensive studying material can be used if quick and easy navigation within the material is provided, for example, by using synchronized narrated slides such as enhanced podcasts.

Keywords
Mobile learning, e-learning, mobility, studying, higher education
Sammanfattning


En designbaserad forskningsansats har använts, och denna avhandling diskuterar och föreslår både vetenskapliga och praktiska bidrag. Ett antal iterationer av OMS har utformats, instansierats och testats i universitetskurser och har utvärderats med hjälp av olika metoder.


Den andra forskningsfrågan är hur kan OMS-aktiviteter och -innehåll designas för att stödja effektivt studerande i OMS-situationer. Studerandeaktiviteter som identifierats som särskilt lämpliga för OMS-situationer är de som fokuserar på förberedelser och repetition. Dessa aktiviteter kan förstärka annat lärande och effektivt studerande kan ske även om endast lite tid finns att tillgå. Exempel på metoder för detta som framgångsrikt testats i denna avhandling är advance organizers och flashcards. Längre och mer utförligt studiematerial kan användas om snabb och enkel navigering i materialet möjliggörs, exempelvis genom användning av synkroniserat ljud och bilder, såsom enhanced podcasts.

Nyckelord
Mobile learning, e-learning, mobility, studying, higher education
Preface

In 2003, I had almost given up on my research studies in graphic arts production. I had found that teaching and mobile technologies caught my interest much more than printing presses. But then came a turning point when I stumbled upon an article from the Stanford Learning Lab with the title “Mobile learning explorations at the Stanford Learning Lab” (E. Brown, 2001). The first sentence in the article was, “Cell phones, Palm Pilots, wireless Web - they help us check email, trade stocks and stay in touch - but can they help us learn? Can we, should we, try to fill in gaps of daily time with learning opportunities?”

The article described some early prototypes for mobile language learning, and they provided a vision: “The SLL’s vision was to fill in gaps of time -- to create a bubble of learning that you carry with you, but may only access for periods of 30 seconds or 10 minutes at a time. Being mobile correlates with highly fragmented attention, and the challenge was to better understand what kind of learning can happen in those fragmented pieces of time.”

At the time, I was recently married and was struggling to learn Finnish. However, I found myself constantly lacking the time to study, and as a university teacher I found this to be a common problem among my students as well. Could this be the solution to both the students’ and my own problems with finding time to study, to spend the 60+ minutes I travelled to and from work every day learning Finnish? Over a year that could mean 200+ hours studying, and that would mean I would learn Finnish in no time, right? And because I was teaching 85% of my time, it would be possible to use my own courses as a test bed for this research. This would make it possible to actually complete a thesis in less time than the 27 years it would nominally take to do this at 15% per year.

After discussing this with my (Finnish) professor, we agreed that I should completely change the topic of my research studies and should begin studying this relatively new area. The working title was “Mobile Learning in Fragmented Time” or more popularly “Finnish at the Bus Stop”.

This thesis describes this journey into uncharted territory. The journey has not been straight, but the quotations above have always been the guiding theme. I believe I have learned a lot and come to some interesting conclusions. I hope you can also learn something by reading this thesis.
There are many people other than myself without whom this dissertation would not have been possible. Chronologically, I would first of all like to thank my parents Gunnar and Kerstin, and my brother Niklas for an upbringing that was both supportive and inspired me to pursue an academic career. My wife Heli has further played an essential role by both supporting me and by asking (or nagging) me about when she should start planning the dissertation party. My children Casper and Vilma have, apart from being a constant source of joy, also unknowingly supported me by making me much more productive at work in order for me to have time to focus more on them while not working.

On the academic side I would first like to thank my supervisors over the years. Nils Enlund’s supportive attitude when I wanted to change topic of my research was essential, and later my current supervisors Stefan Hrastinski, Daniel Pargman and Olle Bälter have provided invaluable feedback on how to structure and make sense of what I have done. I would also like to thank Johan Lundin who at my final seminar provided me with a new and better way to look at my work, and to Henrik Artman who took time during his summer vacation to do the internal quality review of the thesis.

Many other colleagues have played an important role by making me enjoy my workplace as much as I do. They are too many to include here, so I choose the three colleagues, Leif Handberg, Alex Jonsson and Christer Lie, who have been with me all my years at KTH. Finally I would like to thank Fredrik Enoksson with whom I had many valuable and interesting dissertation-related discussion during a couple of summer weeks when we both were struggling with the final parts of our dissertations.

Stockholm, August 2014

Björn Hedin
PAPERS INCLUDED IN THIS THESIS


PAPERS NOT INCLUDED IN THIS THESIS


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Outline of this thesis

Chapter 1 starts with introducing why this research is relevant, establishes what I mean by Opportunistic Mobile Studying (OMS), and argues that commuting is one important opportunity for OMS. It ends by outlining the research objectives.

Chapter 2 presents my views on science and knowledge that have guided this work with a focus on design-based research. The evaluation methods are presented and discussed, and a normative foundation for what to aim for is set.

Chapter 3 presents the knowledge base that has been used for grounding the experimental design and the theory that has been used to make sense of the results. It starts with research on studying activities and media content to establish a basis for efficient studying, and this is followed by theories related to motivating behavioral changes.

Chapter 4 presents the design iterations. The presentations are focused on the published papers but extend the papers by more thoroughly discussing design choices, reflecting on impact in an OMS context, and relating the results to more recent iterations and developments.

Chapter 5 describes the findings within a broader context and presents more general conclusions. It first presents more general scientific contributions and then presents suggestions for practitioners based on the experiences from the designs. It ends with a reflection on choices that were made and provides suggestions for future work.
1 INTRODUCTION

The advancement of the Internet and mobile technology has had an enormous impact on most aspects of young people’s lives. They have the ability to connect with each other using mobile phones and social media, and they expect a multitude of services to be available through the Internet and their mobile devices.

However, higher education has not changed as quickly as its students and society as a whole. While the media industry has rapidly taken advantage of the new mobile technology, thereby populating otherwise “wasted time” with music, social media, news, movies, etc., there are still very few examples of students using these available time slots for studying. One observation states:

“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; these will not be adopted and, hence, will not become sustainable.” (Wingkvist 2009, pp. 3-4)

This thesis approaches this issue by exploring how to design systems and activities using mobile technology for studying during “inter-time”. This is the time that takes place between activities (Scherer & Scherer, 2007, p. 122) that often occurs in unconventional learning contexts such as when traveling on a bus or when waiting in a line. To motivate why this could be a good idea for many students, we need to start with a fundamental aspect of our lives: Time.

1.1 THE VALUE OF TIME AND TIME MANAGEMENT

Time is becoming more and more valuable in our society. According to the scarcity hypothesis, people place the greatest subjective value on resources that are scarce (Inglehart, 2000). Garhammer (2002, pp.219-220) interprets this in the context of time, “Individuals as well as societies place the greatest subjective value on those things which are relatively scarce: As disposable time runs short in advanced societies as
well as in certain life-cycle phases, time becomes upgraded in the value system.” The perceived lack of time is also highly visible in today’s society. For example, in Sweden a perceived lack of time is the fourth most commonly discussed topic during coffee breaks at work (Larsson & Kollind, 2003).

The acceleration of life has resulted in two ways in which one can attempt to use time more efficiently. The first is the contraction of time in which one spends less time on particular activities, for example, by eating faster. The second is the compression of actions by squeezing more activities into a given time frame by either reducing breaks or by doing more things simultaneously (Garhammer, 2002), thereby “freeing” valuable time for other activities.

While it can be debated whether either of these two are actually desirable, both of these strategies for making more efficient use of time are commonplace (ibid). The focus of this thesis is on exploring the possibilities of studying using the second strategy. This involves studying during breaks between other activities (so-called “inter-time”), that is, in contexts not normally considered traditional studying moments or environments. Doing this could free up time that could be considered more “valuable”, such as evenings, for either more learning or other activities such as socializing with friends and family.

How to manage this valuable asset is called time management. Time management has many definitions as reviewed in (Claessens, Eerde, Rutte, & Roe, 2007), but the one finally suggested in their literature review is “behaviors that aim at achieving an effective use of time while performing certain goal-directed activities” (ibid, p.8). As pointed out in their review, time management strategies might differ between employees and students because students generally have the possibility to postpone activities, such as not taking an exam, but this option is usually not available to employees (ibid). Results from the reviewed studies consistently show that good time management skills are positively correlated to perceived control of time and job satisfaction and are negatively correlated to job-induced and somatic stress (ibid).

1.2 OPPORTUNISTIC MOBILE STUDYING

Mobile learning, or m-learning, is a relatively new research area with some of the earliest academically organized events taking place in 2002 with the International Workshop on Mobile and Wireless Technologies in
Education in Sweden and in 2003 with the MLEARN conference in Birmingham. As the name suggests, the central concepts are learning and mobility. However, several different definitions of mobile learning exist, with each having different meanings.

Kukulska-Hulme et al (2009, p.20) state, “Research into mobile learning then becomes the study of how the mobility of learners, augmented by personal and public technology, can contribute to the process of gaining new knowledge, skills and experience.” This captures two essential aspects common to most definitions of mobile learning; the mobility aspect (which will be discussed further below), and the technology aspect. Thus, sitting on a bus and reading a traditional course book does not, according to this definition, constitute mobile learning because the technology part is lacking.

One common focus of mobile learning is to take explicit advantage of the context. A well-known definition of mobile learning is “the processes of coming to know through conversations across multiple contexts amongst people and personal interactive technologies” (Sharples, Taylor, & Vavoula, 2005). Time, place, preferences, availability of friends, mood, surrounding, previous knowledge, and several other factors all contribute to a complex context that will influence the effectiveness of different mobile learning activities. Because we constantly move between contexts, the conditions for mobile learning constantly change and this gives rise to new learning opportunities.

I have chosen to focus this thesis on what I call Opportunistic Mobile Studying (OMS), which I see as something related to, but not the same as, mobile learning. The most significant difference between the two is that OMS will explicitly not consider the context except for very general contextual information such as time in relation to other studying sessions, duration of the current studying session, and the place where an opportunity to study occurs. In addition, OMS does not focus on learning or the outcome of learning, but rather on the act of studying as a behavior or activity that hopefully leads to learning. The reason for these choices is that I want to develop general solutions that keep as many doors for studying open as possible, thereby increasing the possibilities of having something to study when an opportunity occurs. Developing solutions that take advantage of more specific contexts might limit the generalizability to these contexts. Developing solutions for a specific interpretation of what learning is, such as deep learning, surface learning,
1. INTRODUCTION

behavioristic learning, or constructivistic learning would also limit the possibilities for use, and I believe that all the interpretations of learning above have merits in different situations. Studying, however, is an activity that can be seen as a behavior and, as such, it can be measured and quantified and interventions can be designed to change the behavior.

Turning to the word “mobile”, Weilenmann (2003) poses the question of what mobile really is and gives four answers – mobile individuals, mobile settings, mobile information, and mobile technology. According to Weilenmann, mobile individuals includes individuals moving, e.g., walking, but can also include “mobile workers” and “nomads”, people who are mobile as a result of their work. This category will not be considered further in this thesis. Mobile settings are those where the individual is more or less stationary, but the whole setting is moving, e.g., while traveling on a train, airplane, or bus. While this is a prime candidate for the kind of studying envisioned in this thesis, I will not exclude opportunities for studying in non-mobile settings such as sitting on a sofa or waiting at a bus stop. Mobile information is information that can be accessed remotely in mobile contexts. This is often a great advantage, but not always a strict necessity for OMS because content can be downloaded in advance. Finally, mobile technology is generally considered a requirement in definitions of mobile learning. In this thesis, the focus of the word “mobile” is on mobile technology, and the primary technological device considered is the smartphone.

In turning to the word “opportunistic” in OMS, we have to go back 2500 years in time. The ancient Greeks used two different words for time, kairos and chronos (Kinneavy & Eski, 1994). Chronos was what we today might label “quantitative time” or “clock time”, while kairos had a qualitative dimension (ibid). Kinneavy (1986) defined chronos as “the right or opportune time to do something...”, and the Merriam-Webster’s dictionary defines it as “a time when conditions are right for the accomplishment of a crucial action: the opportune and decisive moment”. Merriam-Webster’s dictionary further defines “opportunity” as “a favorable juncture of circumstances” or “a good chance for advancement or progress”, and defines “opportunistic” as “taking advantage of opportunities as they arise”.

In this thesis, I argue that the concept of chronos is very important when discussing OMS. While it is indeed possible to study anywhere and anytime using mobile technologies, I will argue that the importance of
matching the activity and time of the activity is very important. The driving force for \textit{wanting} to study in the case of OMS is that there is an \textit{opportunity} (or a \textit{favorable juncture of circumstances} as per the definition above) to study \textit{something}, and that a suitable activity, with a perceived \textit{good chance for progress} (as per above) is made possible by the presence of mobile technologies. This leads to my definition of OMS.

\textbf{Definition:} \textit{Opportunistic Mobile Studying} is studying during inter-time using mobile technologies where the driving force for studying is a \textit{favorable junction of circumstances with a perceived good chance for making sufficient progress}.

I will argue that it is possible to design OMS so both the circumstances are more favorable and the chances for progress increase, and that it is possible for a system to identify good opportunities for OMS.

\section*{1.3 \textbf{When do Students have Time for OMS?}}

The focus of this thesis is studying during inter-time. There is, of course, an abundance of moments between other activities, but here I will make a case that commuting and traveling are prime candidates for such studying even if I do not exclude other opportunities. The main reasons for this are that students in general spend much time traveling, these moments occur with regularity, and they have clear cues or triggers that are important for building habits as will be discussed later.

Research shows that studying or working while traveling is the most significant feature for making travelers consider their travel time “very worthwhile” (Vilhelsson, Thulin, & Fahlén, 2011). The same research, however, shows that there is a significant drop in studying frequency when the travel time is short, and that even for students spending several hours traveling each day more than 50% do not spend any of that time studying (ibid). This could point to an interesting opportunity to design studying in such a way as to increase these numbers.

Another reason for why commuting could be an important candidate for OMS is, as briefly mentioned above, because the time spent by students commuting is often considerable. Statistics Sweden carries out a survey every 10 years about how the Swedish population spends its time.
The data (SCB, 2011)\(^1\) show that the average Swedish student (aged 20–84 years and including part-time students, those involved in study circles, etc.) studies for 25 hours per week and that 48% of the students travel in connection to their studies for an average of 9 hours and 34 minutes per week. The time spent traveling has increased drastically over the last 20 years with an average increase of 3 hours and 23 minutes per week. (ibid.)

Travel associated with leisure is 7 hours and 21 minutes per week. Even though it is not strictly scientifically correct to add numbers for different groups, this gives an indication that for about 50% of the students, roughly 17 hours per week are spent traveling either related to studying or leisure (ibid.), or about 70% of the time actually spent studying!

The Harmonised European Time Use Survey (HETUS) includes time study data from 15 European countries and shows similar statistics where travel time associated with studying and leisure amount to almost 8 hours each per week or a total of 16 hours (SCB, n.d.). This shows that these figures are similar in Sweden and the rest of Europe.

These statistics show that a large number of students spend considerable time traveling or waiting, inter-time that could potentially be spent studying so as to either increase the amount of learning or to free up time for other activities that would otherwise have been spent studying.

Much of this inter-time we use ICT. In a study of commuters in Sweden, about 10% used laptops, and when they did they used them for an average 40 minutes on a 55 minute trip (Vilhelmson et al., 2011). The use of mobile phones in general is increasing very rapidly, and a recent study (Nielsen, 2014) shows that on an average people today spend more time connecting to the Internet with a cell phone than with a computer (Figure 1). However, these statistics alone do not help us understand how to design OMS and we need to have a better grasp on what people actually do with their mobile phones and why.

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\(^1\) The statistics are divided by gender. Because the gender differences are relatively small and not significant, the simplification made here is that the numbers listed are the numbers for males plus females divided by two.
1.4 What People Do with their Mobile Phones and Why

The study by Nielsen (2014) shows that the lion’s share of time spent on smartphones is spent using various apps. Traditional mobile phone functions such as calling, texting, and accessing the address book only constitute about 14% of mobile phone use in the U.S. and even less in Japan and Italy (Nielsen, 2014). It appears that the mobile phone is becoming less of a traditional telephone and more of a multi-media and communication device. From a designer’s perspective, some general categorizations have been developed to describe the reasons why people use mobile apps. For example, Clark identifies three reasons – “micro-tasking”, “I’m local”, and “I’m bored” (J. Clark, 2010) – and Google user experience designer Leiland Reich identifies the following three similar reasons: “Repetitive now”, where a user performs some action again and again; “Bored now”, where the user has some time on hand and wants something to do; and “Urgent now”, where a user needs to do something right now such as finding an address (Wellman, 2007).

Research has also been done on why people use mobile phones. For example, one study examined why people use mobile phones at home and found that laziness was an essential aspect (Nylander, Fådal, & Mottaghy, 2012). Even though computers were available, mobile phones were used instead. The reasons for this were, for example, that using a computer would require that it be started, the computer could be located too far away, or simply because the user did not have the energy to get up from...
the couch or to get out of bed (Nylander et al., 2012; Nylander, Lundquist, Brännström, & Karlson, 2009).

The studies above suggest two opportunities where OMS could replace other activities during inter-time moments. The first opportunity is commuting, which is a situation where the traveller is waiting to get to their destination. Waiting is a source of boredom (Conrad, 1997), and boredom, as mentioned above, is one of the main reasons for using mobile devices (J. Clark, 2010; Wellman, 2007). However, it should be noted that perceiving waiting as something boring might be a cultural phenomenon that is most pronounced in Western culture, and in other cultures waiting might be perceived as an opportunity to do other things such as socialize (Conrad, 1997). The second opportunity is the laziness aspect where a student could have an opportunity to study at home, but accessing the learning material might be perceived as requiring too much effort. Here mobile access to learning content can be the solution that makes the difference between studying and not studying.

Most students are pressed for time, but they still have plenty of time when they are bored, for example, while commuting. A rational solution for freeing up more time for other activities would seem to be to spend that time studying. However, it is not certain that students will take advantage of such opportunities, even if they rationally believe it is a good idea. One of the main goals in this thesis is to describe how interventions can be designed to make studying prevail over other mobile phone activities in situations like this one.

1.5 RESEARCH OBJECTIVES

The aim of this thesis is to explore how opportunistic use of mobile devices for studying in higher education can be designed. The work done can be viewed as a “design space exploration”, which refers to “the activity of exploring design alternatives prior to implementation” (Kang, Jackson, & Schulte, 2011, p.33). This means that the approach has been relatively broad within the area of study instead of focusing on one specific aspect and exploring that aspect very deeply, but still not so broad as to cover all possible aspects. In order to limit the design space, two main research questions have gradually evolved that focus on adoption and efficiency. These two essential aspects of OMS must be addressed if the practice is to become widespread.
Most mobile learning initiatives have not been adopted and have thus not become sustainable (Wingkvist, 2009). OMS competes with a multitude of attractive activities that can easily be accessed in OMS situations, and, therefore, one major challenge is to design OMS so that the students will adopt the behavior of studying at opportune moments instead of choosing other activities. This leads to research question one.

RQ1: How can OMS be designed to support students in adopting the behavior of studying at opportune moments?

Related to RQ1, it would be desirable that the studying be as efficient as possible. If students choose to study but the efficiency is much lower than if they had spent the same amount of time studying in a traditional learning environment, then the OMS moment might be better spent doing some alternative activity or relaxing instead. In other words, choosing to study in such a situation would not be a rational behavior. This leads to the second research question:

RQ2: How can OMS activities and content be designed to support efficient studying in OMS situations?

The outcomes in the papers include methods and different instantiations of OMS that contribute to answering these research questions. The contributions of the papers are presented on two levels. The first level is the specific contributions of each iteration, and these are presented after the description of each paper in chapter 4. The conclusions of the combined effort – and suggestions for practitioners – are presented in chapter 5.

### 1.6 Delimitations

I have chosen to limit the design space and not include the possibilities to communicate and interact with fellow students using mobile phones and have focused solely on individual studying. I have also not included purely audio-based solutions, which would have increased the design space to include inter-time such as when walking or doing housework. Almost all of the studies presented in this thesis were conducted on students enrolled in media technology courses at Swedish universities, and this might limit the generalizability of the results to other groups.
2 RESEARCH APPROACH AND METHODS

What is research, what is knowledge, and how does one perform research in order to produce knowledge? These questions do not have universal answers, but differ within different academic disciplines. It is not trivial to position this thesis within a single academic discipline. This thesis is cross-disciplinary in nature, touching on disciplines such as media technology, didactics, and engineering, but perhaps the best single discipline that combines most of the above is Technology Enhanced Learning (TEL). The rest of this chapter is about the standpoints I have taken in conducting this research within TEL.

2.1 ENGINEERING, SCIENCE, AND KNOWLEDGE

In my view, the first goal of empirical science is to find out facts about different aspects of the world. After these facts have been established, the next goal is to try to find an explanation for why the world is the way it is and behaves the way it does. Finding out these facts and these explanations can have value in itself, or the knowledge can be used to improve the reality we live in. To develop solutions to improve the reality we live in is the typical role of an engineer. Shaw (1990, p.15) defines engineering as “creating cost-effective solutions to practical problems by applying scientific knowledge to building things in the service of mankind”.

Being an engineer, and the definition of engineering presented above, has influenced the approach I have taken in the research for this thesis. The “practical problem” has been how to support students to study in OMS situations, and the “cost-effectiveness” has been finding solutions that would not require unrealistic resources in terms of time or money on the part of the universities or the students. The work has been grounded in scientific knowledge from research mainly in learning and behavioral science. The “things” have been both methods and instantiations that have been tested in real environments, and finally the “service of mankind” has been my belief that, if widely used, the solutions could have a direct and meaningful impact on higher education. What is missing from Shaw’s definition from a research perspective is the production of new knowledge. But what is new knowledge in this case?

Epistemology is the field of philosophy that deals with the nature of knowledge. The field seeks to provide answers to questions like “what is
knowledge”, “how do we gain knowledge”, and “what do we know”. Aristotle made an important distinction between factual knowledge (episteme), which is to know what or why, and action knowledge (techne), which is to know how to do something. It is into this latter category that engineering science and medical science primarily fall (Hansson, 2007).

Knowledge in the broad field of education falls into both categories. The purpose of didactics is primarily geared towards the practicalities of how to make learners learn, but in order to achieve this we need to take a pedagogical perspective on the theoretical knowledge of learning itself. Research in TEL is, in my view, the combination of engineering science with didactics and/or pedagogy, and its main goal is to make, and to make use of, technology for learning purposes. Knowledge in this field is, therefore, knowledge of how technology can be used for learning purposes (techne) more than the actual learning processes or content of the learning.

Over the years, my view of my own contribution to knowledge has shifted. Initially, my view was that the solutions I developed were mainly the means for evaluating the solutions. The knowledge constructed was empirical; what new knowledge of the world could be gained by investigating the use of the solutions I developed? After a while, the realization started to grow that the solutions themselves were more interesting than the outcomes of the evaluations, and I started to realize that the main contribution was the “how-to” knowledge rather than the “what and why” knowledge. Therefore, this thesis is now framed as design-science research rather than empirical research.

2.2 DESIGN SCIENCE AND RESEARCH

Seeing design as related to science is a relatively new phenomenon that has gone through three main periods of progress in modern times. The first period was in the 1920s, the second was in the 1960s, and the third is the current period around the millennium shift (Cross, 2001). A common perspective today is that an important difference between design science and empirical or natural science is that design science attempts to “create things that serve human purposes” (March & Smith, 1995, p.253). Rather than having the ultimate goal of producing theory, the goal is to produce artifacts in the form of constructs, models, methods, or instantiations (ibid.). These are explained as follows:
“[c]onstructs...characterize phenomena. These can be combined in higher order constructions, often termed models, used to describe tasks, situations, or artifacts. Design scientists also develop methods, ways of performing goal-directed activities. Finally, the foregoing can be instantiated in specific products, physical implementations intended to perform certain tasks.” (March & Smith, 1995, p 253)

Both design science perspectives and empirical science perspectives are important when exploring OMS. The knowledge gained by studying learning and behavior serves as part of the knowledge base required by design science in order to design scientifically grounded “things” from which how-to knowledge is generated by evaluating the artifacts produced. These artifacts can in turn be studied from an empirical science perspective for developing new theories. Another important distinction between empirical science and design science is that whereas empirical science is descriptive, design science is prescriptive and has a direction that is right or wrong, better or worse (March & Smith, 1995; Wang & Hannafin, 2005).

March & Smith (1995) make a further distinction between the research output and the research activities. Research activities within design science are mainly involved in building and evaluating. Building is the demonstration of feasibility (“does it work”), and evaluation is the measurement of how well the artifact matches the criteria against which success is measured (“how well does it work”) (March & Smith, 1995, p.258). Research activities within empirical science are primarily involved in theorizing and justifying. These activities can also be applied to design research, and in this case theorizing means to come up with a theory about why or how an artifact works and justifying means collecting data to either verify or reject hypotheses or theories (March & Smith, 1995).

March & Smith have developed a research framework that relates research activities to research outputs. Research efforts can be framed by the intersections of these activities and outputs, and such framing will result in different objectives and methods for the research. The design activities in all of the papers in this thesis have been centered around the cross-section of the build and evaluate activities and the method and instantiation outputs (Figure 2).
The work of March & Smith (1995) is mainly focused on research in information technology, but their ideas are applicable in other design areas. For example, the term “design experiments” in a learning setting was first proposed by Brown, who said that her research was to “engineer innovative educational environments and simultaneously conduct experimental studies of those innovations” (A. L. Brown, 1992, p.141), and “design-based research” was later described as “a practical research methodology that could effectively bridge the chasm between research and practice in formal education” (Anderson & Shattuck, 2012, p.16). In their analysis of how the term design-based research has been used within the field of education research, they suggest that it should be defined by a number of components.

One component is that the research should be situated in a real educational context. Papers I, III, IV, V, and VI in this thesis have been conducted in real educational settings with real tasks and real courses. The second component is that there should be a focus on the design and testing of a significant intervention, and this has been the case in all of the papers in this thesis.

As a methodological framework, design-based research is very open to which methods should be used in the evaluation of the studies. Anderson and Shattuck conclude that design-based research “typically involves mixed methods using a variety of research tools and techniques” and that both quantitative and qualitative measurements are commonly used.

<table>
<thead>
<tr>
<th>Research Outputs</th>
<th>Research Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construct</td>
<td>Build</td>
</tr>
<tr>
<td>Model</td>
<td></td>
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<tr>
<td>Method</td>
<td></td>
</tr>
<tr>
<td>Instantiation</td>
<td></td>
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</tbody>
</table>

Figure 2. The research in this thesis mapped within the framework of March & Smith (1995).
(Anderson & Shattuck, 2012, p.17). The choices of evaluation methods in the studies in this thesis are described in the next section.

Another significant practice in design-based research is that such research usually involves multiple iterations (Anderson & Shattuck, 2012). Papers II–VI were to a minor or major extent iterations originating from paper I but following different branches. To complement my own studies, I have also initiated and supervised several B.Sc. and M.Sc. thesis projects that have provided the possibility to make excursions into areas I would not otherwise have had time to investigate on my own. These branches, and the student involvement in these research projects, are discussed in chapter 4.

Finally I want to clarify my view on the differences between design, research-based design, and design-based research within TEL. Design within TEL can be when a teacher comes up with an idea of how to use some kind of technology in their practice to solve a problem. For example, a teacher might have found that many of the students have problems attending the course lectures and so decides to provide pre-recorded lectures that would be available online. This problem serves as the

![Diagram](image_url)

**Figure 3.** Design, research-based design, and design-based research as adapted from Hevner (2007).

*requirement* for a design process in which the teacher tries to design a pedagogical and technical solution that works, develops this iteratively,
and then does field testing in his class. This would be a design approach. If, however, the teacher grounded the designs in the available knowledge base (to the right in Figure 3) before starting the design process, for example, by developing a theoretical pedagogical framework based on previous research on similar problems, then this would be considered research-based design. If the teacher went even further and aimed not only at finding a solution for his particular problem or practice, but also aimed at a serious evaluation and to add the new knowledge gained in the problem area to the knowledge base, then this would be considered design-based research. The work in this thesis is primarily design-based research, and the small part about procrastination is in the form of empirical science research.

2.3 EVALUATION METHODS

As previously mentioned, design-based research is very open as to which evaluation methods to use (Anderson & Shattuck, 2012). I have chosen a mix of quantitative and qualitative methods, and an overview of these are shown in Table 1.

Table 1. Overview of Papers and Methods.

<table>
<thead>
<tr>
<th>Paper / Method</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prototypes developed and tested in course</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Questionnaires</td>
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<td>X</td>
<td>X</td>
<td>X</td>
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<td>X</td>
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<tr>
<td>Focus Groups</td>
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<tr>
<td>Log files</td>
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<td>X</td>
<td></td>
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<tr>
<td>Direct questionnaires</td>
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<tr>
<td>Experiment</td>
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<td>X</td>
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<tr>
<td>Reflective essays</td>
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<td>X</td>
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</tbody>
</table>

For papers I, II, III, V, and VI, the respondents were students participating in courses that I was involved in, and this provided the opportunities to gather data as part of the course assignments. Questionnaires were determined to be a suitable way to collect data in all these cases because the response frequency could be expected to be very
high and they would give a broad range of both quantitative and qualitative results.

In order to get more in-depth qualitative results, several other methods were employed to complement the use of the questionnaires. Papers I, II, and IV have used focus groups. Using focus groups is described as a highly efficient technique for qualitative data collection (Robson, 2002). The most extensive use was in paper I where all participants in the first part of the study participated in focus groups that were video recorded and transcribed. Because this was a requirement for participating in the project, there was no problem in getting respondents for the focus groups. Papers II, or rather an earlier version of the paper (Hedin & Lindgren, 2006), and IV both used focus groups to some extent. Paper I used log file analysis to determine exactly when the students accessed the content along with “direct questionnaires” in order to get immediate feedback on each piece of media content sent out. Paper II used an experimental method with a controlled environment in order to gather objective data on reading comprehension. Finally, paper V used reflective essays where students wrote two-page reflections on their own procrastination habits. This allowed for a deeper understanding of the students’ procrastination habits than what could be gathered from the questionnaires.

A problem arises in design-based research when the researcher and teacher are the same person because of the intimacy of the researcher with the design, development, pedagogical approach, and field tests. The interventions and interactions are not merely observed, but are actually caused by the researcher, and this can influence the objectivity of the researcher (Barab & Squire, 2004). However, others argue that this adds as much as it distracts from research validity because “[design-based research] also requires comradeship, enthusiasm, and a willingness to actively support the intervention”, but the narrow line between objectivity and bias must be walked with care (Anderson & Shattuck, 2012).

2.4 Methodological critique

As mentioned in the delimitations, one problem with the approach above is the limited ability to generalize the results to a broader population. Almost all the respondents in the studies were young Swedes who were interested in technology and competent in the use of media technology. However, the focus on this group does provide a deeper understanding of
this specific group instead of more diffuse knowledge about a broader group.

Deeper qualitative data collected in a dialogue with the students would also have been good. Qualitative data was gathered by use of questionnaires and by the use of focus groups, but it would have been preferable to have more focus groups. However, because there was no budget to provide any financial compensation to the participants and because the studies had to be conducted within a strict time frame, the option of getting only some in-depth results was considered better than no in-depth results at all.

2.5 Normative Foundation

As previously mentioned, one of the characteristics of design-based research is that design science is normative or prescriptive in the sense that it provides a direction that guides action. In some areas, perhaps especially in engineering, this is relatively uncomplicated and includes concepts such as “faster”, “more bytes”, and “higher resolution”. In the case of designing how to make students study in new situations, however, choosing which direction to take is not trivial. Rational choice theory is a widespread and generally applicable theory for how choices are, or should be, made. According to this theory, choices are made based on an analysis of the cost and benefit of the outcome (Beekhoven, De Jong, & Van Hout, 2002). The theory has been used in a wide variety of fields, such as economics, political science, and sociology (ibid.), and the theory does seem applicable in many cases, not least because of its accordance with common sense (Herrnstein, 1990). However, the theory has also received much criticism as more and more examples of non-rational behavior have been found and more and more experiments show that people in many cases act irrationally (Ariely & Norton, 2008; Ariely & Wertenbroch, 2002; Kahneman, 2003; Steel, 2007). For example, smoking habits, drug abuse, buying lottery tickets, eating habits, and so forth are all examples where people know certain actions are not rational, but act that way anyway. Herrnstein (1990), however, argues that “The theory of rational choice fails as a description of actual behavior, but it remains unequaled as a normative theory. It tells us how we should behave in order to maximize reinforcement, not how we do behave.” In a studying context, this means that one should seek to maximize the perceived effect of studying while minimizing the
cost. This can be expressed as learning as much as possible in as short time as possible and with as little effort as possible.

I will use rational choice theory as a normative theory in order to provide a foundation for what to strive for. This means, for example, that if there is a choice between spreading out studying over six ten-minute intervals compared to one one-hour occasion, and the former leads to better retention (if retention is the goal), then the former would be a rational choice and this should be strived for.

In this thesis, I argue that there are several generic studying activities that in many cases, either from a rational or efficiency point of view, would be a good choice of activity in mobile contexts. However, as mentioned above, students often do not behave rationally even if they want to. An example of this is procrastination, which is studied in papers V and VI. In order to design OMS so it will actually be adopted, we will have to consider how to change people’s behavior from how they actually behave to how they would like to or feel they ought to behave, which is my normative standpoint in this thesis.
3 Theory for Designing OMS

This chapter presents the “knowledge space” in which my research is grounded as presented in section 2.2. How this knowledge is directly related to the specific iterations is integrated into the presentations of the iterations in chapter 4 under the subheadings “design principles”. This is also revisited when the conclusions are presented in the last chapter.

Given the normative foundation established in the last chapter, one of the goals for OMS is that it should be efficient because using the time for inefficient studying would generally be irrational. “Efficient studying”, however, is not something that is easily defined. The definition of “efficient” according to dictionary.com is “performing or functioning in the best possible manner with the least waste of time and effort”, and the related word “efficiency” is defined as “…the ability to accomplish a job with a minimum expenditure of time and effort.” Achieving some kind of goal with a minimum expenditure of resources is also an intuitive interpretation of efficiency.

In the case of studying, however, the goal is not as straightforward as one might think because the students’ approaches to their studying can differ, and the goal of studying might not even be to learn but rather to pass an exam. Marton and Säljö (1976) proposed that a student can take a deep or a surface approach to learning, which was later complemented by the addition of the strategic approach (Entwistle, 1988). According to Lublin (2003), the characteristics of a deep learner include a focus on actively seeking to understand the material that is driven by an interest in the subject and is often associated with a constructivistic learning model (Tynjälä, 1997). A surface learner’s focus is rather on reproducing the knowledge that is presented – often driven by a fear of failure rather than interest in the subject matter – and this learner focuses more on repeating what they have learned, memorization, and the use of rote learning (Diseth & Martinsen, 2003). Today such learning is often associated with a behavioristic learning model (Tynjälä, 1997). Finally, a strategic learner focuses on gaining as high a grade as possible by optimizing their performance on the assessment, for example, by organizing their time and distributing their effort to the greatest effect (Diseth & Martinsen, 2003). Depending on which of these views one takes, what constitutes efficient studying will differ; a good strategy for
passing an exam might be a bad strategy for learning and vice versa. I choose not to take a normative stand on this because there can be complex underlying reasons for a student’s learning approach in a specific course, and a student could have perfectly good reasons for choosing one approach over the others.

The second problem with the concept of “efficient studying” is the challenge in optimizing studying based on two different parameters, time and effort, especially because “effort” is a very subjective measure. For example, in paper II the optimization of reading speed was based only on the objective measurement “time” because this allowed for the possibility to perform statistical analyses. However, as seen in the discussion of the same paper, the “effort” of using the proposed technique was seen as significant by many of the participants, and this might have reduced the efficiency compared to if the optimization was done based on both time and effort.

Given this introduction to the complexity of discussing “efficient studying”, this chapter starts by presenting a number of theoretical aspects that have been the driving principles when designing the artifacts in the different studies. The first aspect considered is preparation and repetition, and this is related to the effects of spreading studying out over several shorter sessions instead of concentrating it into one longer session. It concerns how to best schedule a fixed amount of time over an extended time frame in order to achieve maximum effect. Second, the efficiency related to the chosen media format of learning content used on mobile devices is covered in an attempt to answer the question of how the challenges imposed by the small screen of a mobile phone can be overcome.

Next follows theoretical aspects related to how to design for achieving the target behavior of making students actually study during appropriate OMS moments. The basis for this is the Fogg Behavior Model, which is first introduced and then followed by the three factors – motivation, simplicity/ability, and triggers – that influence how to design for a target behavior. In relation to the section on motivation, the Temporal Motivation Theory is covered, which I suggest is more appropriate for describing motivation than the original motivational model. Finally, individual preferences, distractions, and multitasking are discussed.
3.1 Preparation and Repetition

One possible use of short available time slots is to repeat what has been studied previously. The efficiency of this can be substantial, and there are plenty of examples of this. For example, Mayer (1983) and Bromage and Mayer (1986) studied the quantitative and qualitative effects of repetition on learning from technical texts and from science prose. The quantitative effect, that readers recall more by repeated exposure of content, is “is one of the best established findings in the psychology of learning and memory” (ibid.), but they also found that repeated exposure was beneficial for several qualitative aspects of learning such as better remembrance of structurally important information. It should be noted that repetition is not necessarily the same as rote learning, for example, it can involve the use of reflective questions as in paper I. Repetition for OMS was used in the designs in papers I and IV.

Another way to use repetition while studying is by preparing in advance for an upcoming studying session by getting an overview of the topic to be studied. David Ausubel has developed Subsumption Theory (Ausubel, 1962) that describes how new material being studied is absorbed better, or subsumed, if it can be related to, and integrated into, existing cognitive structures and existing ideas. An instructional method for applying subsumption theory proposed by Ausubel was the use of advance organizers (Ausubel, 1960), which are short introductions to topics that facilitate the organization and retention of upcoming study sessions (Stone, 1983). Current examples are expository organizers that describe the new content the students will be exposed to (Marzano, Pickering, & Pollock, 2001) and skimming organizers for skimming the content that should be studied, for example, by using the SQ3R technique described in the next section (Hill & Flynn, 2006). In different meta-analysis studies, advance organizers have been found to have significant positive effects on both learning and retention (Luiten, Ames, & Ackerson, 1980; Stone, 1983). Advance organizers were used in the design in paper I and to some extent in paper III.

A more recent study of advance organizers in a mobile context used what was called “Technology Based Advance Organizers” (TBAOs). In this study, the TBAOs were 4–6 minute long video podcasts for iPods that were used in an English learning class (Billings & Mathison, 2012). These were used much as envisioned in this thesis – on bus rides to and from the museum where the main learning activity took place – and showed a
significant increase in performance tests when viewed in this way (on an iPod on a bus ride) than when the same content was shown on a DVD. The TBAOs were also used for repetition to further reinforce learning.

Another well established theory of the effect of repetition on learning is the spacing effect (Dempster, 1988; Ebbinghaus, Ruger, & Bussenius, 1913; Wozniak, 1995). This theory states that if given a fixed amount of time to study, substantially better long-term retention is generally achieved by repeating the content on several different occasions spread out over time than by using a longer period of time for massed presentation of the content (Dempster, 1988; Kornell, 2009). This effect is “one of the most dependable and replicable phenomena in experimental psychology” (Dempster, 1988, p.627), and while most studies have involved recall-like activities on the lower levels of Bloom’s taxonomy (Bloom, 1956), several studies have also shown that the effect applies to higher levels of learning such as the learning of scientific and mathematical concepts (Reynolds & Glaser, 1964 in Dempster, 1988) and arithmetic rules (Gay, 1973 in Dempster, 1988).

A tool for taking advantage of the spacing effect is flashcards (Kornell, 2009). Flashcards are traditionally a deck of cards with a question on one side and the answer to the question on the other side. These can then be used for memorization. A structured way to determine when to review which cards is called “spaced repetition” and studies have shown that they are an efficient way to take advantage of the spacing effect (ibid). For example, the Leitner system is an analog flashcard system for spaced repetition that uses five different boxes to store the cards. New cards are added to the first box. The content of box one is reviewed most frequently, and the content of box five is reviewed least frequently. When reviewing the content of a box, the student looks at the question of a card in the box, thinks about the answer and then looks at the answer. If the answer was not known it is moved to the previous box, and if the answer was known it is put in the next box. If the students keeps remembering the answer, the card will finally end up in box five, and if it is still remembered in box five it will be considered remembered “forever” and is removed from the boxes. (Leitner, 1972).

Even though there is substantial evidence for the benefits for retention by taking advantage of the spacing effect, the results regarding spacing effect vs. massed presentation, or “cramming”, on academic achievement are mixed. Cramming is when most of the studying is “crammed” into the
last few days before an exam. The existence of cramming is visible in research. For example, in one study cramming was measured as the number of hours spent studying as a function of time until the exam. The results showed that with 84 days left until the exam the number of hours spent studying was a bit more than one hour per day, but with four days left until the exam the number of hours spent studying was about seven hours per day (Schouwenburg & Groenewoud, 2001). In a study by Vacha and McBride (1993), and contrary to their hypothesis, students with cramming strategies got grades as good or better than those with other strategies. One of the reasons why cramming strategies can result in high academic achievement is that there is little time to forget when cramming, thus student scores are boosted by short-lived memories (Kornell, 2009). Other studies have shown, not surprisingly, that strategic learning strategies (i.e. focusing on how to pass an exam rather than to learn) can be a good predictor of academic achievement (Diseth & Martinsen, 2003). One conclusion can be that for students interested both in learning and in passing exams, both cramming and taking advantage of the spacing effect can be effective.

3.2 Efficiency for Different Media Formats

Text-based content is very common learning material in higher education, and being able to efficiently read such material on mobile devices would open up many possibilities to access learning in OMS situations. However, reading is not a unitary activity and can have different purposes requiring different techniques. Van Doren et al. (1972), differentiated between reading, for example, a novel, which is most often a linear process, and “active reading”, which is used for learning and usually involves much more interaction with the text. Much of the reading done on mobile devices today is linear reading, such as reading news, email, or text messages, and this means that general practice for reading on mobile devices might not be applicable to OMS. For students, reading often means reading to be able to answer questions at a later date (Lorch, Lorch, & Klusewitz, 1993). This generally requires re-reading, efficient navigation back and forth, skimming, and reviewing previously read topics (O’Hara, 1996).

For many of these requirements, paper is often considered better than screen (O’Hara, 1996). O’Hara and Sellen (1997) found navigation on paper was quicker and less disruptive of reading than reading on screens.
One problem was not being able to see a complete page in on-line documents, and this hampered the incidental memory from quickly finding previously read portions of the text (ibid). This applies when reading content on small-screen devices such as mobile phones, although technical improvements in recent years have reduced these differences.

Romberger (1998) has studied the problem of getting an overview of a text on a computer screen as compared to reading the same text on paper. He argues that getting an overview of a text involves building and using a mental representation of the text, and his results show that getting that kind of overview on a computer screen is more difficult than on paper. For example, the spatial placement of the content helps the spatial memory, and this is much more difficult to achieve in a scroll-based mode than a page-based mode. However, his results also show that these problems are reduced in shorter texts. Page-flipping is also an important aspect to get an overview of the text and is another case where paper is superior to screens. (Romberger, 1998). These problems escalate when reading text on a mobile phone rather than a computer screen due to the even more limiting size of a mobile phone screen.

There are several reading strategies that have been proposed for how students should read texts. O’Hara pinpoints the SQ3R (Skim/survey, Question, Read, Recite, Review) strategy first proposed by Robinson (1941) as a good model for the reading activities that take place while learning (O’Hara, 1996). Several studies have shown a positive correlation between use of SQ3R and grade point average (Beneke & Harris, 1972; Briggs, Tosi, & Morley, 1971; Driskell & Kelly, 1980; Heerman, 1972 in Artis (2008)). SQ3R has since developed into newer techniques along the same lines for self-regulated reading, with abbreviations such as PQ4R, SQ10R, and SQ6R (Artis, 2008). The common pattern among these reading strategies is that the first step is to skim, survey, or preview the material (S or P) in order to get an overview of the structure of the text and the main idea(s). The next step is to develop questions about the text (Q) that are then used for directing the next active reading steps (R). These active reading steps consist of a number of other activities starting with the letters “re-”; recite, review, reflect, repeat, rethink, reiterate, rehash, reintegrate, renote, reevaluate, and reread, with the common theme that they process the material over and over again. The overall common pattern is to 1) become familiar with the text, then 2) to formulate questions to facilitate using more active reading techniques to
comprehend the material, and finally 3) to revisit and review the material and the learning gained from the material.

Skimming, reading, and re-reading are all possible in OMS situations, but these can be challenging due to difficulties in reading and navigating texts on mobile devices. Paper II deals with an alternative means of reading text, which could be particularly useful on small screen devices. The technique is called Rapid Serial Visual Presentation (RSVP). Using this technique, the words in a text are not displayed in a spatial dimension, but rather in a temporal dimension with words being displayed sequentially on the same spot on the screen in rapid succession. This has two advantages when reading on mobile phones. The technology is particularly suitable because it requires very little space, thereby making the small screen on a mobile phone a non-issue. The other advantage is that it can increase the reading speed by eliminating the common practice of regressions in which the reader, often unconsciously, goes back one or several words in the text and which constitute a substantial amount of the reading time (Just & Carpenter, 1980). Studies show that reading with RSVP can be done with very high speed while still retaining high comprehension. For example, in an experiment by Rubin and Turano (1992), reading speed for RSVP was consistently higher than for reading in page-mode. The average reading speed was 1171 words per minute for RSVP, and the maximum reading speed for page-based reading was 303 words per minute. Such extreme results, however, are uncommon, and a more recent study showed that for longer texts reading speed was about the same for RSVP as regular reading, but for shorter texts reading speed increased by 33% (Öquist & Goldstein, 2003). In this context, it is also relevant to note that normal reading speed on paper in general is much higher than speech with about 250 words per minute (Rayner, 1998) for reading English compared to 120–140 words per minute for speaking, for example, southern American English (Cherry & Taylor, 1954), and this has implications if comparing text-based material with audio books.

An interesting idea regarding learning from text-based material is that making a text slightly more difficult to read can actually increase learning. This is called the disfluency effect (Diemand-Yauman, Oppenheimer et al. 2011). In their study, the researchers let the participants read texts, some of which used common typographical practices and some of which were made harder to read. Surprisingly
enough, the participants learned better from the texts that were harder to read. The explanation in the report is that reading was made more “disfluent” and required the participants to be more focused to be able to read the texts thereby increasing the learning. Furthermore, when transferred to a high-school classroom, the results suggested that significant improvements in educational outcomes could be obtained (ibid). However, the authors point out that this does not by necessity imply that reading material should be made harder to read in order to increase learning. The difficulties imposed could also lead to students becoming frustrated and less motivated to study thereby acting counter productively.

Even though text has many advantages, not least due to the abundance of learning material available and the simplicity of producing new content, one of the advantages of modern mobile devices is their ability to handle multimedia. The Cognitive Theory of Multimedia Learning was proposed by Mayer (1997), and its bearing principle is that students learn better using a combination of the audial and visual senses, such as an animation combined with narration rather than an animation combined with text (Mayer, 2009; Mayer, 1997). The theory draws on several previous theories on memory and learning and results in five principles of how to design multimedia for learning.

According to the “multiple presentation principle”, it is better to explain something using both words and pictures than just one of the modes alone. The cognitive explanation is that the learner can then create two different representations, one visual and one verbal, and then build connections between the two (ibid).

According to the “contiguity principle”, words and pictures should be presented contiguously rather than sequentially, which is explained by the fact that in order to build connections between the two representations they should both be in working memory at the same time.

According to the “split-attention principle”, words in a multimedia presentation should be presented as an auditory narration rather than as on-screen text. This is explained by the fact that the visual information channel can become overloaded if it must take in both words and images. If they are separated as audio and images, both the visual and the auditory processing systems can be used.

According to the “individual differences principle”, the previous effects are stronger for learners with limited previous knowledge on the subject
than those with more comprehensive previous knowledge on the subject. The effects are also stronger for those with high spatial abilities than with low spatial abilities. The explanation in the former case is that those with more previous knowledge on a topic can more easily build their own mental images while watching an animation or reading a text so contiguous presentation is not as important. Likewise, those with high spatial abilities can more easily hold visual images in working memory thereby reducing the effect of contiguous presentation.

Finally, according to the “coherence principle” extraneous words and pictures should be avoided rather than elaborating on interesting but not essential topics. The explanation is that shorter, more to-the-point presentations make it easier for the learner to select and organize the information productively.

### 3.3 Fogg Behavior Model

That the studying is efficient is not the only important issue for OMS. If the students still do not use OMS even though it is efficient, it will still not be of much use. The Fogg Behavior Model (FBM) is described as a behavior model for persuasive design (Fogg, 2009), and it can be used both to design and analyze technology intended to be used for persuasive purposes. The model was published after papers I–IV were published, so the designs in those papers did not take the FBM directly into account, but many of the design choices and results are closely related to the model. I will use the FBM to frame some of the findings and to suggest how the model should be interpreted and used in an OMS design perspective.

First a note on terminology. A “behavior” in the FBM can be described as an “act”, and a target behavior is an act that someone wants to happen. Fogg outlines a grid in which behavior change designs can be categorized (Fogg & Hreha, 2010). One axis of the grid is the duration of the behavior, which can be a one-time “dot” behavior such as filling out a more complete profile on a social media site, a time interval “span” behavior, such as not drinking coffee for one month, or a permanent “path” behavior such as always turning off the lights when leaving the house (Fogg & Hreha, 2010). The other axis is the “flavor”, which indicates the type of behavior, and this is labeled with colors to make it more memorable. The “green” behavior is a new and unfamiliar behavior, the “blue” behavior is a familiar behavior, the “purple” behavior is an
increase in the intensity or duration of a behavior, the “gray” behavior is a
decrease in the intensity or duration of a behavior, and finally the “black”
behavior is stopping a behavior (Fogg & Hreha, 2010). The grid is
illustrated in Table 2.

Table 2. Fogg’s behavior grid

<table>
<thead>
<tr>
<th></th>
<th>Green</th>
<th>Blue</th>
<th>Purple</th>
<th>Gray</th>
<th>Black</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dot</td>
<td>Green dot</td>
<td>Blue dot</td>
<td>Purple dot</td>
<td>Gray dot</td>
<td>Black dot</td>
</tr>
<tr>
<td></td>
<td>Do a new behavior one time</td>
<td>Do a familiar behavior one time</td>
<td>Increase a behavior one time</td>
<td>Decrease a behavior one time</td>
<td>Stop doing a behavior one time</td>
</tr>
<tr>
<td>Span</td>
<td>Green span</td>
<td>Blue span</td>
<td>Purple span</td>
<td>Gray span</td>
<td>Black span</td>
</tr>
<tr>
<td></td>
<td>Do a new behavior for a period of time</td>
<td>Do a familiar behavior for a period of time</td>
<td>Increase a behavior for a period of time</td>
<td>Decrease a behavior for a period of time</td>
<td>Stop doing a behavior for a period of time</td>
</tr>
<tr>
<td>Path</td>
<td>Green path</td>
<td>Blue path</td>
<td>Purple path</td>
<td>Gray path</td>
<td>Black path</td>
</tr>
<tr>
<td></td>
<td>Do a new behavior from now on</td>
<td>Do a familiar behavior from now on</td>
<td>Increase behavior from now on</td>
<td>Decrease behavior from now on</td>
<td>Stop doing a behavior from now on</td>
</tr>
</tbody>
</table>

In the case of OMS, the work will mainly be in the green categories
because most students will not have used OMS before. The duration
might initially aim for a dot behavior, that students will try a solution at
least once, but then move into the span or path durations.

Turning back to the FBM, the following three factors are relevant for a
desired behavior to happen: motivation, ability, and triggers. There are
other models that are to many extents similar, for example, Ripple (1955)
describes a model with the relatively corresponding terms of motivation,
capacity, and opportunity. However, the FBM’s focus on persuasive
technology, behavior change rather than attitude change, and triggers makes it especially suitable for my purposes.

According to the FBM, motivation to perform an action and the ability to perform that action (or simplicity in performing that action) are both highly important for the likelihood of actually completing the activity. If you are highly motivated but find your ability to perform an action is low (for example, due to a difficult user interface, mentally straining activities, or lack of time) the activity will likely not happen. The same goes for high ability (good interface, simple tasks, and plenty of time) but low motivation. However, when both motivation and ability are high, the conditions for the behavior to occur increase dramatically. This line of reasoning is in agreement with common sense, but it is still quite common that the desired action is not performed as shown, for example, by research on procrastination (Steel, 2007).

According to Fogg (2009), the missing part is often the trigger. For a trigger to have best effect it must 1) be noticed, 2) be associated with the desired behavior, and 3) fire at a moment when both motivation and ability are high. On the other hand, if motivation or ability is low and a trigger is fired, it could easily become a nuisance. Thus the timings of the triggers are essential.

These three aspects of the FBM will be described in the following sections. I will also make a side-trek into Temporal Motivation Theory as an alternative model for motivation in OMS and then provide a concluding discussion on distractions and multitasking.

### 3.4 Motivation

In the FBM, the core motivators are pleasure/pain, hope/fear, and social acceptance/rejection. This is a very general model that is suitable for many purposes, but for education there could be other more relevant models for how students are motivated. During the work of this thesis, I have found procrastination to be a very relevant parameter for determining when students have the motivation to study.

Procrastination is defined as “to voluntarily delay an intended course of action despite expecting to be worse off for the delay” (Steel, 2007, p.66), thus procrastination is obviously not a very rational behavior. Yet, it is very common, especially among students. Steel has undertaken the most comprehensive meta-analysis on procrastination to date and has analyzed the results of 553 procrastination studies. This analysis showed
that 80%–95% of college students procrastinate, about 50% consider it problematic, and 95% wish to reduce it (Steel, 2007). Other studies have shown that the amount of time students procrastinate is considerable, often occupying over 1/3 of their available time (Pychyl, Lee, Thibodeau, & Blunt, 2000). Procrastination is also closely related to cramming and massed presentation because studying is postponed until the last moment. Because procrastination is so common and because it means that students do not study even though they think they should study, it is a very interesting phenomenon to explore in this context.

3.5 Temporal Motivation Theory

Temporal Motivation Theory was proposed by Steel and König (2006) and was an attempt to develop a broad, integrated theory of motivation that takes procrastination into account. A central concept both for Temporal Motivation Theory and procrastination is “utility”. Utility, according to Steel and König (2006), indicates the preference for a specific course of action and they define utility as

\[
Utility = \frac{\text{Expectancy} \times \text{Value}}{\text{Sensitivity to delay} \times \text{Delay}}.
\]

Expectancy is the belief in one’s own capability to complete a task, and value is how rewarding it would be to complete the task. In the denominator, delay refers to how long you have to wait for the reward (in a broad sense), and sensitivity to delay is how sensitive you are to delaying the reward. In other words, the utility will increase if the value of an action is high and if you believe it is likely that you will succeed in achieving the outcome. The utility will decrease if there is a long delay before the reward is “cashed in”, and this is affected by how sensitive you are to such delays. In a studying context, the value of studying could be, for example, the sheer joy of learning something new or an increased possibility of passing an exam. The expectancy of a study session is high if you believe you will learn what you set out for and is low if you do not. If the perceived value is an increased chance to pass an exam, then the time to the exam date is the delay parameter and the sensitivity-to-delay parameter would be how important that delay is on influencing whether you will study or not. The introduction of the delay and sensitivity-to-delay parameters are what makes this theory especially useful for discussing motivation and studying because these are basic characteristic for procrastination.
Steel suggests a number of interventions for all of the parameters. For sensitivity-to-delay interventions, Steel recommends reducing distractions and increasing organization, and his main suggestion for accomplishing this is a combination of stimulus control and automating choices. The reason for automating choices is because the fewer the choices, the less the risk for procrastination, and by imposing routines on yourself the decisions are removed (Steel & König, 2006). For delay-related interventions, Steel suggests that making proximal goals, and thereby reducing the distance between action and reward, decreases procrastination (ibid).

Temporal Motivation Theory provides a good model for when students prone to procrastination would be most willing to study when an OMS opportunity presents itself. This makes it easier to know when to fire triggers for reminding the students to study. It should be noted that Temporal Motivation Theory focuses on extrinsic motivation – where the motivation comes from an external source – and this can be contrasted to intrinsic motivation. While intrinsic motivation is generally considered a stronger motivating force than extrinsic motivation (Werbach & Hunter, 2012, location 674), affecting intrinsic motivation is outside the scope of this thesis, except for the autonomy principle of self-determination theory (Werbach & Hunter, 2012, location 714) according to which a sense of being in control increases motivation.

3.6 ABILITY/SIMPLICITY

After this side-trek into Temporal Motivation Theory, we go back to the second factor in FBM. The ability, or simplicity, factor in the model has six parts according to Fogg (2009). These six parts form a “simplicity chain”, and the chain is only as strong as the weakest link in the chain (ibid). The first part is time. If you do not have enough time for an activity, the ability will be low. This is a highly relevant component in this thesis both because of the discussion on time and its value in section 1.1 and because available time can be very short in OMS situations, which reduces ability if the learning requires more time than is available. The second part is money, which can have relevance if solutions require access to either equipment that is expensive or have other costs such as for data traffic. The third part in the model is physical effort, but this has little bearing on OMS. The fourth part, “brain cycles”, is relevant to OMS because learning often requires a substantial mental effort and energy
levels can differ between different OMS situations. The fifth part is “social deviance” where there can be a social price to pay for going against the norm, something that can have bearing, for example, if studying on mobile phones is considered “too geeky”. The sixth and final part is if the behavior is part of a routine or not, and it is assumed that routinely performed activities are simpler to perform. Automating activities, or making them into habits, is also one of the interventions to decrease procrastination, as previously discussed.

According to Duhigg (2012), in order to form a habit the following three components must be considered: a cue, the routine that is triggered by the cue, and the reward that is received by performing the routine. The loop is closed because the reward reinforces the association to perform the routine when noting the cue. This is called “the habit loop” (Duhigg, 2012) as illustrated in Figure 4.

For example, the cue can be a sensation of hunger, the routine can be going to the cafeteria and buying something to eat, and the reward can be a relief of the hunger sensation. According to Duhigg (2012), changing a habit that already exists can be done if the routine that follows a cue is changed and the new routine still gives the same reward. OMS situations can have clear cues, for example, when boarding a bus or picking up a mobile phone when bored, and one type of reward could be the relief of boredom as previously discussed. Using a mobile phone is also something that very easily becomes an automated behavior that become tightly associated with a triggering context or cue, such as a bus trip (Oulasvirta, Rattenbury, Ma, & Raita, 2012).

Fogg argues that the ability/simplicity of a task at a particular moment is a function of the weakest link in the chain. In OMS situations this can, for example, be that if all circumstances are favorable except for a lack of
time, or if all circumstances are favorable except a lack of energy, the task will still not be considered simple enough.

### 3.7 Triggers

The third factor in FBM, after motivation and ability, is a trigger. Fogg identifies the following three different types of triggers: spark triggers, facilitator triggers and signal triggers, each of which serves a different purpose.

A spark trigger is suitable if the person needs to be motivated and serves to increase the motivation to perform the desired activity. I argue that, in accordance with procrastination research and Temporal Motivation Theory, timing and deadlines are key motivational aspects that can be used for spark triggers. This will be discussed further when the results from papers I, III, IV, V, and VI are discussed.

A facilitator serves to increase the ability or simplicity of a task, thus making it easier to perform. In an OMS situation, key factors for this are that there is sufficient time to perform the suggested activity and that it is easy to commence the activity. This will be discussed further when the results from papers I and IV are discussed.

Finally, a signal trigger is effective when the person has both high motivation and high ability to perform the desired activity, and this serves just as a reminder, which is discussed in papers IV, V, and VI.

### 3.8 Individual Preferences

Studying in fragmented time in unconventional physical learning environments, such as when commuting or on your living room sofa, is a challenge due to a number of factors, and finding a solution that fits all students will not be possible. The Dunn and Dunn Learning-Style Model, or Learning Style Inventory (LSI), is described as “... individual’s personal reactions to each of 21 elements when concentrating on new and difficult academic knowledge and skills” (Dunn and Griggs 2000). According to this model, these reactions can make identical instructions effective for some students and ineffective for others (ibid). Curry, in a review of different learning styles, reported that the LSI has “one of the highest reliability and validity ratings” (Curry, 1987). Due to its focus on instructional preference, or the individual’s choice of learning
environment, it is especially relevant to mobile learning as described in this thesis.

The 21 elements are grouped into the following five categories of stimuli preferences: environmental, emotional, sociological, physical, and psychological (Dunn, Griggs, Olson, Beasley, & Gorman, 1995). Four of the elements are especially interesting for fragmented learning in distracting environments, namely sensitivity and preferences regarding sound, the design of the studying environment, persistence, and the time of day. These will be discussed in more detail in section 5.5.

3.9 Distractions and Multitasking

Distractions and multitasking are two aspects that are generally considered to affect learning negatively even though there are individual differences (Adler & Benbunan-Fich, 2013; Bowman, Levine, Waite, & Gendron, 2010; Fox, Rosen, & Crawford, 2009; Gaudreau, Miranda, & Gareau, 2014; Hembrooke & Gay, 2003; Judd & Kennedy, 2011; Junco & Cotten, 2012; Risko, Buchanan, Medimorec, & Kingstone, 2013; Sana, Weston, & Cepeda, 2013). Because distractions and interruptions are abundant in OMS situations and directly affect the studying situation, the solutions should be designed with this in mind.

Distractions or interruptions can be categorized as external or internal (González & Mark, 2004) where external interruptions can, for example, include noisy environments or incoming text messages and internal interruptions include things like mind-wandering. Studies have shown that external distractions and multitasking cause lower comprehension, lower test scores, and lower retention (Fox et al., 2009; Risko et al., 2013; Sana et al., 2013).

Research further shows that the duration for which a student can stay focused is very short. In a study investigating task-switching while studying among 6,000 students, the average task session took 42 minutes, and the median time between task-switches was 5 minutes (Judd & Kennedy, 2011). Other research has shown that students experience attention lapses about every 5 minutes, with increasingly shorter periods between attention lapses as the study session proceeds (Bunce, Flens, & Neiles, 2010), and still other research has shown show that students lose focus on an average every third minute even during a study session as short as 15 minutes (Rosen, Cheever and Carrier, 2012, location 1995). Mind-wandering has been shown to have negative
consequences on educational tasks such as reading comprehension (Smallwood, Fishman, & Schooler, 2007), but there are also studies indicating that short scheduled interruptions every 5 minutes can aid concentration (Stuart & Rutherford, 1978). The conclusion from the same study is that the optimal length of a lecture is 30 minutes.

Mobile device distractions are also abundant. A common cause for task-switching includes technological distractions such as social media and texting (Rosen et al., 2012). Studies show that young people receive text messages on average about every 15 minutes and that more than half check their text messages more often than every 15 minutes (Rosen et al., 2012; Smith, 2011).

One student thesis project initiated as part of this dissertation investigated the use of mobile phones among university students. They found that students started mobile apps on average between 55 and 195 times per day (average 121 apps) and averaged 9.5 hours per day during which they did not start any apps at all (Evaldsson & Åbyhammar, 2013). This means the average number of apps started were about 8 apps per hour. Starting an app can either be a result of external factors such as an incoming notification or internal factors such as mind-wandering.

In summary, many OMS situations have an abundance of external distractions, and distractions have negative impacts on learning. However, there are plenty of distractions anyway, including both external distractions generated by notifications on mobile phones and computers and internal distractions such as mind-wandering.
THE RESULTS PUT IN CONTEXT
4 THE RESULTS PUT IN CONTEXT

This chapter describes the findings from the papers mainly from a design-research perspective. The descriptions of the papers are not merely summaries of the results, but also contain discussions and background sections highlighting the iterative aspects in a broader context that is not visible in the papers on their own. Little focus has been given to motivating the design choices made in the papers themselves, so for each paper the design principles and the grounding of the designs in the research knowledge base are discussed. Next follows a description of the intervention and how it was evaluated. The results section contains the results that are most relevant to this thesis as a whole, and this is followed by problems that in many cases led to new iterations of the intervention. The presentations of the papers also contain a section of recent and relevant developments since the publishing of the papers. After that follows a reflection or discussion where the results are framed more clearly in the context of this thesis, and, finally, conclusions and recommendations from an OMS perspective are presented.
4.1 Paper I


**Background:** This paper was my first venture into the territory of mobile learning, and as such contained the first iterations of the OMS intervention that generated ideas for later studies. The work was a part of a research project called MUSIS (Multicasting Services and Information in Sweden) in which software for delivering media content to Symbian Series 60 mobile phones had been developed. The project in general looked at examining how such a system could be used for all different kinds of services, but the work in this paper focused on delivering content related to higher education to students. The research questions were to find out which kinds of education-related services and content the students were interested in, which media formats were preferred for different kinds of content, and, finally, how to design simpler systems with similar functionality that could be used on a wider range of phones. A special focus was on exploring methods for how to deliver learning content suitable for mobile phones. The idea was also to use the outcome of this project as input for further iterations.

In the framework developed by March & Smith presented in section 2.2, the research output is primarily the methodological contribution of studying using RSVP and secondarily on the instantiation of the OMS intervention. The focus of the research activities is roughly equally distributed between the evaluation and the building of the activity.

**Design principles:** One of the more important design choices was to adapt advance organizers for mobile phones and to use push technology for delivering them to students. The use of advance organizers was motivated by the fact that they are short and it was assumed that the study sessions in the OMS intervention would also be short. They would also be useful both for preparation and repetition, so the spacing effect could be taken advantage of. The advance organizers were designed like outlines of what would be covered during the lectures, and they could also be used for repetition after the lectures. In the third phase of the OMS intervention, they also included keywords, questions, and literature references. The timing of when the content was delivered to the phones could not be individualized, so all students received content at the same
time. For content related to learning it was rather arbitrarily chosen that it should be delivered 4–5 days before the event they covered, so the students would have plenty of time to use the content.

**Intervention:** The intervention was conducted in three iterations. In the first and second iterations, the students in two courses were equipped with mobile phones on which the special MUSIS software was installed along with pre-paid phone cards. With this software, the students could subscribe to different “channels”, such as course information. Other kinds of channels were also used, such as fun, entertainment, music, lunch menus, and so on, but these were not evaluated in this study except as a comparison of the relative interest in mobile educational services compared to other educational services. The teacher could then publish content in these channels, which was then automatically downloaded to the mobile phones where the students received a notification – or a spark trigger according to the FBM. With one exception (see below) the triggers were also facilitator triggers that required just one click to view the content. The content could be any kind of media file, including html files, video or audio files, or eBooks.

The course channel was mainly used to send short text introductions – designed as advance organizers – about upcoming lectures. The channel was also used to send various kind of course-related messages, like reminders of deadlines, instructions on how to prepare for lectures, topics to think about regarding previous and upcoming lectures, and so on.

In the third iteration, a completely separate system was developed based on the findings of the first two iterations. This third iteration was based entirely on SMS and mobile web pages, and this made it available for use in practically any course. It was tested in two courses where links to “lecture packages”, adapted for use on both mobile phones and computers, were sent by email and SMS the day before each lecture. These messages with links can be seen as facilitator triggers. The lecture package contained four pages, one with a summary of the content of the lecture, one with keywords, one with suggested literature, and one with review questions related to the lecture (Figure 5).
All efforts in this paper fell into the green span in the Fogg Behavior Grid described in section 3.3 because these involved performing a new behavior for a period of time.

**Evaluation:** The first two iterations in this study were conducted among all participants in two courses ($n_1 = 18$, $n_2 = 16$) who were given mobile phones and pre-paid phone cards. A condition for participating in the course was that the students also had to participate in a number of questionnaires and focus groups, and this meant we got 100% participation from the whole population of students taking the courses. In the second iteration, instant feedback questionnaires were added based on the results from the first iteration. Using this, the students’ interest in each text-based message was collected along with information on whether the length of the message was considered too short, too long, or just right. Finally, log files of when the content was viewed were used in all iterations.

**Results:** The results showed that education-related channels were considered to be the most useful of the various services tested. In particular, the advance organizers and the course information were appreciated by the students. Access to the messages on mobile phones was considered superior to email because the mobile phones were always nearby.

The preferred media format was clearly text. One of the main reasons for this was that it was considered easier to skim content in text format than to skim audio or video content. The instant feedback showed that
89% thought messages with 444–850 characters were of appropriate length, and 40% of the students felt that messages with 1450–3297 characters were too long. The importance of simplicity in the user interface was also emphasized. A one-click solution was clearly preferred. A one-click solution could not be implemented for eBooks because when receiving the notification of new eBook content the eBook file had to be saved first and then opened. This was considered too non-simple, and this was one of the main reasons why these files were used very sparingly, as was predicted by the FBM.

There was a clear preference from the students to get messages with course information close to the date of the corresponding event even if the same information had been available in other forms at the beginning of the course. In general, all kinds of reminders, especially just-in-time reminders were highly appreciated. In the results from the third phase, we found that 43.2% of the reading events took place before the lecture, and 56.8% took place after the lecture, indicating that the lecture packages were used both to prepare for lectures and to review lectures. On average, each summary was read 45.9 times, which, because the total number of students was only 34, meant that at least some students read the content more than once.

**Problems identified:** Several problems were identified that formed the basis for what to focus on in the upcoming iterations. One problem was the difficulty of presenting longer text-based content on mobile phones. This led to paper II where an RSVP-based solution was tested. Another problem was to present content, especially longer content, using video and in a way that the video-based content was easier to skim through. This led to paper III where video content was delivered as enhanced podcasts. Another problem was that reminders were appreciated, but they often did not lead to direct action. This eventually led to paper IV where location-based reminders were tested. Finally, the high interest in reminders was a first spark of interest that led to papers V and VI where procrastination is covered and led to the interest in the applicability of the FBM.

**Reflection and recent developments:** Since the time of writing paper I, the technical development of mobile phones has been significant, and this has greatly expanded the opportunities to use advance organizers in mobile contexts. In 2004, smartphones were a very new concept with limited media capabilities, small displays, and high
costs for data traffic. Smartphones today are almost ubiquitous and have much better displays and media capabilities. This, in combination with flat-rate prices for mobile data, will allow for much broader possibilities to use audio, video, and interactive advance organizers. Another way to distribute advance organizers is to take advantage of the increased use of mobile phones as calendars. Using the synchronization possibilities for course schedules, teachers can add links to the advance organizers as well as incorporate the advance organizers themselves directly into the schedule, as shown in Figure 6. This could help expose the students to the advance organizers and thus facilitate the development of mobile study habits.

In section 3.2, Technology-Based Advance Organizers were discussed with an example of 4–6 minute long video segments that were watched on an iPod on bus rides before and after the actual learning (Billings & Mathison, 2012). From a technical point of view, these were relatively similar to the enhanced podcasts used in Paper III. Because these were very positively received by the students in that study, it would not be far-fetched to believe that shorter versions of enhanced podcasts might serve well as advance organizers and would add the benefit of simplified navigation.

**Contribution:** The main lasting contribution of paper I was the method to use advance organizers on mobile phones as a tool to get students to both prepare for upcoming lectures and to review previous lectures. This had not been done before, and it proved successful. Another contribution was the insight that reminders were a very high priority for the students and that the reminders should be sent close to the date of the corresponding event. At the time, the implementation of a system that could send out advance organizers to phones was also a contribution, but due to technical developments since then there are now easier ways to achieve the same functionality.
My contribution to the paper: The software used in phases one and two was developed by a project partner company in the MUSIS project. The design and implementation of the focus group study was a collaborative effort between the project partners. All other parts of the study, including the idea, data collection, analysis, forming of conclusions, and writing of the paper was done by me.
4.2 Paper II


Background: The results from paper I indicated that text was a preferred platform for delivering content and information but that it was considered difficult to read text on small screens, especially longer texts. This initiated the design iteration in paper II where the problem we aimed to solve was how to present learning content on small screens. A special focus was on a solution that would be suitable for skimming content. Skimming content is a way to prepare for a later study session and makes that session more effective and efficient as indicated by previous studies on advance organizers and the SQ3R family of reading strategies, both of which were discussed in section 3.2. In the framework developed by March & Smith presented in section 2.2, the research output is primarily the methodological contribution of studying using RSVP and secondarily on the instantiation. The primary focus of the research activities was on evaluation and secondarily on the build activity.

Design principles: After a literature review, RSVP was identified as a plausible solution to the issues raised in paper I. The technology in itself had existed and been refined over several years, but to apply it to mobile phones in a studying context had, as far as we could find, not previously been investigated. The main reason for choosing to evaluate RSVP was that the solution ought to be relatively independent of screen size. Because previous research had indicated that reading speed on computer screens using RSVP could be increased compared to traditional reading on computer screens without significantly decreasing reading comprehension, there were reasons to believe that the effect would be even greater on mobile phones where the small size is an inherent problem for reading. Furthermore, previous research had suggested that RSVP would be particularly good for skimming texts using, for example, the previously discussed SQ3R technique as a way to prepare for upcoming studying sessions.

Prototype: For the purpose of this study, a java-based prototype was developed for use in mobile phones. The prototype used the latest knowledge available at the time for making the reading experience as good as possible, such as adding short pauses at the end of each sentence and displaying long and complex words for a longer time than short,
simple words. The paper included in this thesis is actually the second iteration of the intervention, the first being presented in a previous paper (Hedin & Lindgren, 2006). In the first iteration, the technique was also tested on a broader public of 500 people using it to read news because the prototype could read RSS feeds.

**Evaluation:** The evaluation was done by loading the prototype with several reading comprehension tests taken from the SweSAT tests (“Högskoleprovet”) and letting 83 media technology students from two universities read the texts using both RSVP with two pre-set speeds (fast and normal) and traditional scrolling. To evaluate how the prototype could be used to support efficient reading, **comprehension** was measured in the same way that SweSAT tests measure reading comprehension, and **reading efficiency** was measured as reading comprehension per unit of time. The students’ subjective preferences of RSVP vs. traditional scrolling were measured using a Likert scale of their like or dislike for the different reading modes.

**Results:** Five hypotheses were tested, and the three that gave interesting results are presented here:

**H3: Preference rating is independent of reading mode.**

This hypothesis could be rejected \((p = 3 \times 10^{-8})\), and significant differences were seen between all modes except between fast-paced scrolling and fast-paced RSVP. Of special interest, however, was the high standard deviation of fast RSVP. A total of 37% of the respondents rated fast-paced RSVP as equal to or better than self-paced scrolling, and on an absolute scale they rated the experience as neutral or better. This suggests that 37% of the students could or would consider using RSVP instead of the commonly used self-paced scrolling method.

**H4: Text comprehension is independent of using self-paced scrolling or fast RSVP given that the user’s preference rating for fast RSVP is neutral or better and equal to or higher than for self-paced scrolling.**

This hypothesis could not be rejected using the standard 5% interval, but could be rejected using a 10% interval, and this supported the result that 37% of the students in this group found that fast-paced RSVP gave better comprehension on mobile phones than the standard method of self-paced scrolling.

**H5: Reading efficiency is independent of using self-paced scrolling or fast RSVP given that the user’s preference rating for fast RSVP is neutral or better and equal to or higher than for self-paced scrolling.**
This hypothesis could be rejected \( (p = 0.0006) \), and this provided further support for the finding that learning efficiency, measured as comprehension per time unit, is better than self-paced scrolling for this group of students. The average increase in reading efficiency was 106%.

**Problems identified:** Two problems were identified with the design. The first was that the technical solution was not scalable to a real world setting because the prototype could only be used on very specific handsets and because the content had to be delivered by specific RSS feeds, which would limit the usefulness of the solution in practice. The second problem was that during our internal testing we found that the solution worked very differently depending on the type of text that was being read. For texts with relatively simple content, such as news articles or the reading comprehension tests used in the study, it worked well. However, for more complex content, such as text containing headings, lists, and images or more difficult texts requiring navigation back and forth as discussed in section 3.2, the solution worked much worse.

**Later iterations:** Two more iterations of relevance for this thesis were later carried out as student theses initiated and supervised by me. The first project aimed to develop a solution that would work in the Safari browser on an iPhone and would be able to display ordinary web pages in order to broaden the intervention’s use beyond RSS feeds. The solution worked well from a technical point of view and could display any web page, but the difficulty of how to handle non-content markup on a page, such as navigation menus, was made even more obvious than was experienced in paper II (Yurdakök & El-Noaimi, 2009). The other student thesis aimed at exploring ways to solve that problem, but even though a solution was implemented, the conclusion was that structural information was very hard to render using RSVP (Kotliar, 2009).

**Recent developments:** Many of the problems associated with reading on small screens have been greatly reduced due to the rapid development of screen size and screen resolution on mobile phones. However, other wearable technologies have been developed that have the same problems as older generation smartphones. SmartWatches are one such example, and the screen size of these devices is even smaller than on the mobile phones used in this study. In fact, RSVP has recently received attention as a solution for reading on computer screens, mobile phones,
and SmartWatches with the RSVP solution offered by the company Spritz\textsuperscript{2}. This has also spurred an interest in developing RSVP-enabled reading apps, many of which are now available from various smartphone app stores. Furthermore, this technology can be integrated into web pages, and with the click of a button these can be read using RSVP on a mobile phone and can also be added as a bookmarklet that allows any page to be viewed using the technology, as shown in Figure 7.

![Figure 7](image)

**Figure 7.** To the left is a mobile web page with a Spritz button, and in the middle is a snapshot of the same page displayed using RSVP. To the right is the use of a bookmarklet for displaying a news web page using RSVP.

**Reflection:** The texts used in the RSVP tests were relatively long, around 900 words or about two A4 pages of text. With an average reading speed of 250 words per minute, they would take about 4–5 minutes to read, and with a reading speed of 400 words per minute, which is not unreasonable using RSVP, the texts would take a bit more than 2 minutes to read. This makes the texts suitable for the typical attention span of a student, which is about 3–5 minutes (Bunce et al., 2010; Judd & Kennedy, 2011). As a side note, if the same texts would be studied using an audio book, the time required would be about 7 minutes given the average speed of speech of about 130 words per minute (Cherry & Taylor, 1954). Because audio books suffer from exactly the same problems in terms of navigation, presenting tables, and providing an overview, this

\textsuperscript{2} http://www.spritzinc.com/
would indicate that RSVP would be a much more efficient choice for learning than audio books in fragmented time.

It is further reasonable to believe that with more practice and experience, the preference rating, comprehension, and efficiency would all increase for RSVP. Furthermore, the algorithm for how to pace the words can be improved so as to increase all three factors (Öquist & Goldstein, 2003). One possible explanation for the good comprehension results from this group could be the disfluency effect discussed in section 3.2 (Diemand-Yauman, Oppenheimer, & Vaughan, 2011; Yue, Castel, & Bjork, 2013). This effect means that making a text slightly harder to read can actually lead to better learning.

**Contribution and recommendations:** The main contribution of paper II is the knowledge that a relatively large group of the students (37%) found the experience of reading fast-paced RSVP text to be equal or better than self-paced scrolling. Comprehension for this group was significantly better when using fast-paced RSVP than self-paced scrolling if a 10% confidence interval is accepted, and the reading efficiency was more than doubled for this group. Because previous studies had indicated that both reading comprehension and subjective experience tend to increase with practice, this would indicate that RSVP might be a preferred way of reading for a relatively large group of students.

In the SQ3R family of study techniques, RSVP could be used for skimming/preparing, reading, and revisiting. For all cases, however, the texts should be relatively short in order not to suffer the negative effects due to the lack of overview ability and difficulties with navigation as discussed in section 3.2. In addition, the texts should not contain too many spatial navigational elements that would require a spatial layout as per the results of Kotliar (2009). Also, several types of text by nature require much navigation and slow reading, such as in mathematics, and for these kinds of texts RSVP would clearly be inappropriate. However, the suggestion is to focus on relatively short and simple texts or to use RSVP for skimming.

**My contribution to the paper:** This paper was a collaborative effort between me and a student writing his master’s thesis. The idea was mine, the design was done collaboratively, and the implementation was done solely by the student. The data collection and analysis were primarily done by me, but with significant support from the student, and the paper was mainly written by me.
4.3 Paper III


**Background:** The results from paper I indicated that text was a preferred platform for delivering content and information and that longer content was not appreciated. However, settling for delivering just text-based content for OMS would not be a solution that took advantage of the unique capabilities of mobile phones to deliver audio, video, and graphics. This led to an attempt to design a solution for delivering content that took advantage of these multimedia capabilities, and at the same time an attempt was made to design a solution for delivering longer video-based content. Because traditional lectures are still a very common way of teaching, they were identified as an interesting possibility to explore in this context. In the framework developed by March & Smith described in section 2.2, the research output is in the middle of the intersection between the research outputs “method” and “instantiation” and the research activities “build” and “evaluate”.

**Design principles:** During the initial literature review, a number of aspects for how to design a solution were identified. The first aspects for how to design a solution were taken from three of the five principles in the Theory for Multimedia Learning (Mayer, 1997) discussed in section 3.2. In this theory, the “multiple presentation principle” states that it is better to use a combination of spoken words and pictures than just one of the two modes, and the “contiguity principle” states that the words and pictures should be presented contiguously rather than sequentially. This is much like how a PowerPoint presentation in a classroom is used, which would make a solution based on narrated PowerPoint slides suitable. Furthermore, because many traditional lectures are based on PowerPoint presentations this would make it easier to convert such a lecture than to build a new lecture from scratch, thereby making the threshold for using the design lower for other teachers. The choice was made, however, not to follow Mayer’s third principle, the “split-attention principle”, which says that words should be delivered as narration rather than as on-screen text. This choice was made because the slides would also be available in print format, and these slides would be relatively self-explanatory because the slides were essential for the computer lab assignments associated with each lecture.
The choice was also made to publish the content to both computer and mobile platforms simultaneously because it was expected that most students would view the content from a computer in the foreseeable future. Thus the more niched mobile use would come as a bonus to an adaption to a more blended learning environment rather than becoming a prioritization issue that would have to be compared with other pedagogical development efforts.

Further design choices were based on the fact that most students have difficulties focusing on an entire lecture – as discussed in section 3.9 – and that according to the FBM not having enough time is one of the six parts in the simplicity chain. This led to design choices that focused on making it as easy as possible to navigate the material in the presentation. This would make it easier to find parts that needed to be revised and would also make it easier both to skim and review just a part of the presentation if there was not enough time to view it in its entirety. The first step to accomplish this was to break down a traditional 2 × 45 minute lecture into smaller chunks based on the different topics covered in the lecture. After evaluating different technical solutions, the choice of technical platform fell upon enhanced podcasts which is a format for presenting synchronized slides and narrations. This format also had the benefit of being relatively easy to produce and distribute and had very good navigation capabilities between the narrated slides (Figure 8).

![Enhanced Podcasts]
**Intervention:** The solution was implemented in one of my own courses. The course was structured as a number of lectures, each closely connected to a computer programming assignment in which the principles of the lecture were applied in practice. The course had deadlines every other week, and this was a way to set proximal goals in order to help the students keep a steady study pace as discussed in section 3.5. Three different instances of the same course (course rounds) were examined, one which was given as a regular campus course without the use of enhanced podcasts (44 students), one which was given with both regular lectures and the same lectures available as enhanced podcasts (24 students), and one course in which all but the first lecture were only available as enhanced podcasts (51 students). At the time of the study only 8 out of the 75 students owned suitable mobile devices (such as an iPod) with which it was possible to watch the enhanced podcasts with reasonable quality. The enhanced podcasts consisted of five pre-recorded lectures with synchronized narration of PowerPoint slides that were divided up into nine different parts with lengths varying from 15 minutes to 52 minutes (average 33 minutes) with an average of 27 slides per part. The enhanced podcasts could be watched either from a computer or from an iPod. All PowerPoint slides were also available as pdf files for all three groups. The efforts in this paper fell into the green span in the Fogg Behavior Grid described in section 3.3, which is to do a new behavior for a period of time.

**Evaluation:** The intervention was evaluated using anonymous questionnaires distributed to the students in the three different course rounds. The questions asked how the students experienced the intervention, and these were answered both in free text and with Likert scales. The throughput was measured as the number of students who completed the course on time.

**Results:** The evaluation showed that the two versions of the course that included enhanced podcasts had a much higher throughput than the version without enhanced podcasts, with 96% of the students successfully completing the course on time using enhanced podcasts compared to 61%, even though the group without enhanced podcasts was the group with the highest grade point average in the school. In total, 84% of the students who used them agreed or strongly agreed that the enhanced podcasts were very useful.
The actual production and publication of the podcasts took relatively little time, and once the technology was set up the production and publication took just a bit more time than giving the corresponding lecture.

The results very clearly showed that the ability to instantly find and navigate to the relevant parts of the enhanced podcast was considered very important. This is compared to a video recording where the navigation is still possible but more difficult. Furthermore, the ability to repeat specific parts of the lecture that had not been fully understood was the strongest result of the questionnaire. Seventy-one percent of the students “strongly agreed” that it was very important and the remaining 29% “agreed”.

The large majority (91%) of the students disagreed that a sound-only version would have worked just as well as the enhanced podcasts, and a clear majority of 61% of the students believed that the addition of a video recording of the lecturer would not have made the enhanced podcasts better. Only 11% believed that a video of the lecturer would have been important.

A few negative aspects were also identified. The loss of interaction with the teacher was considered negative by some of the students in the course round using only enhanced podcasts. Another problem some students experienced was procrastination related. If there was a lecture, they would attend it because it was a once-only opportunity. If the content was available offline, they felt they had the opportunity to view the lecture later instead of now, and in some cases that led to students not viewing the lectures at all. In the case of this course, this was partially solved by having bi-weekly deadlines for the lab assignments that helped the students to not postpone viewing the lecture indefinitely.

As for mobile device use, as mentioned above, very few students at that time owned suitable devices. The three students who owned an iPod Nano with a 1.5 inch display with a resolution of 176 × 132 pixels disagreed or strongly disagreed that watching the enhanced podcasts on their iPods was “very useful”. Three iPod owners did not try the enhanced podcasts, but of the remaining five students who owned an iPod with a 2.5 inch display with a resolution of 320 × 240 pixels, two students agreed and three students strongly agreed that watching the enhanced podcasts on their iPods was very useful. All five used the podcasts during inter-time – such as when traveling by bus or train – and three of the five
also used them at home. The mobility aspect was considered very important. All negative comments about using iPods were related to the readability of the small fonts on relatively low-resolution displays. To the hypothetical question posed to all students asking whether they would be very interested in watching enhanced podcasts during inter-time, given that they owned suitable equipment, 51% agreed or strongly agreed, and 27% disagreed or strongly disagreed.

**Problems identified:** From a general practical perspective, one problem was the small number of students who owned a device that could access the enhanced podcasts. Regarding the content itself, the text was considered by some to be difficult to read on the small screens. From a practical teaching point of view, modifying the podcasts after they were recorded was difficult, and from a student point of view transferring the podcasts to mobile units required at least some effort by the students and had to be done while at a computer.

**Later iterations:** When the same course was given in 2009/2010 when 42% of the 90 students who answered the course questionnaire owned an iPhone with which they could watch the enhanced podcasts, the students showed a high interest in using enhanced podcasts during inter-time. A total of 41% “completely agreed” and 20% agreed that they would be very interested in watching education-related enhanced podcasts during inter-time such as when traveling on a train or bus, whereas only 13% disagreed (Hedin, 2010). This indicated that the interest in using the enhanced podcasts on mobile devices had increased significantly \(p = 0.085\) when a critical number of students actually owned mobile technology with which to watch the enhanced podcasts.

The enhanced podcasts that were recorded have since been reused for seven years and a total of 14 course rounds. The year after the interventions, the enhanced podcasts were also made available as non-downloadable slidecasts, which was a format that allowed the content to be viewed in an ordinary web browser and that made gathering statistics regarding the number of views possible. The slidecasts corresponding to the first two mandatory lab assignments in the course have been viewed on average about 1000 times per year with an average of about 100 course participants per year. From the data collected, it cannot be determined how many of these views were made from mobile devices. However, course questionnaires suggest most of the slide casts have been viewed on computers rather than on mobile devices. This is hardly
surprising because on mobile devices the enhanced podcast format is superior. The throughput has averaged 87%, which is substantially higher than before the intervention.

**Recent developments:** Today there are solutions to all the problems identified above. Most students now own a smartphone capable of handling html5 video content, which can be accessed using mobile networks. There are now solutions that can take a narrated PowerPoint file and convert it to html5 with the same navigation capabilities as offered by enhanced podcasts, for example, the solution offered by Brainshark3 (Figure 9). Such solutions also add new features, such as the use of animations. This means the problem of easy access to the content in mobile situations to almost all students can be considered solved. Furthermore, the problem of post-editing content is also solved because a narrated PowerPoint file can be edited on a per-slide basis.

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3 [http://www.brainshark.com](http://www.brainshark.com)
**Reflection:** Steel suggests that making proximal goals, thereby reducing the distance between action and reward, decreases procrastination (Steel, 2007). This has been used in two aspects in this study. The first is that the course has had bi-weekly deadlines, which are proximal goals for the students. This can be one explanation for the high throughput of the course, but the same deadline system was also used before the intervention when the throughput was lower. On a micro level, the podcasts were organized so that it was easy to watch and listen to just a few slides at a time, which would make it easier to consider a goal of “watching just a few slides” a success.

From the perspective of university management, the enhanced podcasts have proven to be very successful in the long run. One practical advantage has been that the content developed is equally useful on mobile phones as on computers, which supports arguments for producing such content even if there are no explicit intentions of using the content in OMS situations. Furthermore, creating, modifying, and distributing the narrated presentation can easily be done by the teacher without any help from professionals or the requirement of special recording equipment. This eliminates two major drawbacks to recording video lectures identified by Odhabi and Nicks-McCaleb (2011) and reduces both the threshold to start and the costs involved. The result is, from a functional point of view, better than a screencast of a presentation due to the better navigation possibilities, which was seen as a distinct advantage in the evaluation. Because they are easier to update, synchronized narrated slides are also more sustainable for courses running for several years.

One of the main results was the high level of appreciation of the ability to quickly navigate to the desired section of the enhanced podcast for repetition and reviewing. This is consistent with strategies for how to read texts for learning that emphasize efficient navigation back and forth and the ability to repeat and review specific parts (Lorch et al., 1993). The enhanced podcasts were also used for all three reading-related parts of the SQ3R technique (preparation, reading/viewing, and reviewing/re-reading) as discussed in section 3.2. The enhanced podcasts used in this paper could be used to prepare by skimming the slides without simultaneously listening to the audio, thereby serving as an advance organizer as presented in section 3.1. Their main use was as learning material corresponding to the “Read” part in SQ3R, but they also served
THE RESULTS PUT IN CONTEXT

as material for easily finding and repeating exactly the parts of the lecture that a student wanted to revise, both with and without audio.

**Contribution:** The main contribution of paper III is the methodology for presenting a recorded lecture as a narrated slide presentation in which it is easy for students to instantly find and navigate to the part they want to review. In addition, this instantiation of the intervention has proven very successful in the long term. The importance of easy navigation is a valuable lesson for anyone interested in developing video-based learning content. The longitudinal use of the enhanced podcasts during the seven years following the study shows that the solution is sustainable and cost effective and that the enhanced podcasts are frequently viewed multiple times for later review. Another contribution is the high interest shown by students to use this solution in OMS situations, although the evaluation cannot confirm whether they actually take advantage of such opportunities.
4.4 Paper IV


**Background:** The results from paper I indicated that getting study-related reminders on their mobile phones was of interest for students and that longer content was considered problematic. This sparked the interest in designing a solution that would combine facilitating efficient studying even for very short lengths of time with reminders of the possibility to study. Therefore, a master’s thesis project was initiated (Malmlöf, 2008) focusing on “micro learning” using flashcards as described in section 3.2. This intervention was implemented as a web solution with pages that adapted to a mobile layout when viewed on a mobile phone. Reminders, or signal triggers according to the FBM, were sent by both email and SMS based on the results from paper I. The evaluation showed two problems with this design. The first problem was that the reminders were sent out based on a time-based algorithm that often turned out to be at inconvenient times, thereby making the reminder more of a nuisance than a support. The other was that the mobile web solution was too slow and required several seconds to load new flashcards. This led to the iteration presented in this paper in which a native flashcard application was developed and the reminders were based on locations instead of time. In the framework developed by March & Smith described in section 2.2, the research output is primarily the methodological contribution of triggering location-based reminders and using flashcards for studying on mobile phones and secondarily on the instantiation. The focus of the research activities is primarily on the build activity and secondarily on the evaluation.

**Design principles:** There were three reasons for deciding to use flashcards. The first was based on the premise that the study session should be short and that it should be “preemptive”. Preemption is a term from computing, and in this context it means the act of interrupting a studying task and being able to resume the same studying task later with a minimum loss of efficiency. Time is also one of the criteria in the simplicity chain in the FBM because not having time to perform a target behavior breaks the simplicity chain. Because a single flashcard takes only a few seconds to review, and can be reviewed out of context with other cards, the solution is both suitable for short study sessions and is
highly preemptive. The second reason was that several short study sessions, according to the research on repetition and the spacing effect, should be suitable for using spaced repetition as discussed in section 3.2, and flashcards are an efficient way to take advantage of the spacing effect. The third reason was that flashcards are very condensed, which makes them suitable for use on small mobile phone screens.

The rationale for how to design the reminders was based on the observation discussed above that time-based reminders were not suitable. Location-based “opportunistic reminders” (Ludford, Frankowski, Reily, Wilms, & Terveen, 2006) have been successful (Sohn et al., 2005) in non-educational contexts, which made them interesting for our purposes. Furthermore, the literature review and the results from paper III indicated that traveling or commuting was a prime candidate for OMS. Therefore, triggering reminders sent when students start commuting ought to be a good design choice, and because commuting often has the same starting points, using locations to detect these starting points was a natural choice. However, the choice was still made to let the students themselves decide the locations where they wanted to be reminded and whether they wanted to be reminded when arriving, leaving, or being at the location. Much effort was put into designing the detection of locations based on GSM cells rather than GPS, which allowed the solution to conserve the phone battery – which was a major issue at the time – but at the cost of reduced accuracy.

**Intervention:** In order to conduct this study, a prototype for mobile phones was developed with which the students could add places where they wanted to be reminded to study. The study material consisted of an associated flashcard system for studying chemistry that was related to a course the students were currently enrolled in. The flashcard system is shown in Figure 10. Eleven students used the application for one week. The effort in this paper falls into the green span in the Fogg Behavior Grid described in section 3.3 and involved performing a new behavior for a period of time.
Evaluation: Both qualitative and quantitative data were collected using log files, pre- and post-test questionnaires, and focus groups. The evaluation primarily aimed at determining the students’ attitudes to using flashcards with location-based reminders to study the flashcards.

Results: Several interesting results came out of this study, but these must be interpreted very carefully due to the few number of participants. Eight out of nine respondents said that they had studied more due to the reminders than they would have if the reminders had not existed, and the most appreciated time to get reminders was when traveling by public transport because the students reported that they usually did not do anything else useful at the time. Furthermore, the students reported that the small size of a mobile phone was better than a book, computer, or notebook when traveling on crowded buses or trains.

The students appreciated that they could choose the locations they would be reminded at because this avoided the feeling of being monitored. Reminders occurring at inconvenient moments were not appreciated, and this indicated the importance of triggering reminders just at the right moments.
Another interesting serendipitous result was that the intended functionality of notifying the students of a learning opportunity by vibration and sound could not be implemented for technical reasons, thereby requiring the students to look at the phone to see the notification. This resulted in several missed reminders, but the students still saw most of the reminders, which must mean that they looked at the phones in these situations anyway. This suggests that reminders could be designed to be shown on the mobile phones at suitable locations, but without an accompanying vibration or sound, which would reduce the problem of reminders occurring at inconvenient moments.

Of interest from a procrastination point of view was the opinion by some of the respondents that studying the chemistry flashcards became a nice break from other activities at home. This is consistent with Perry (1996) who argued that procrastination indeed can be combined with getting things done because procrastinators often do something, just not the thing they think they ought to be doing at the moment. In this case, studying was seen as a way to put off doing something else the respondents did not want to do. Furthermore, the students reported that it was easier to use the mobile phone for 10 minutes rather than open their books for a short time period, and this is consistent with later research on why people use their mobile phones at home (Nylander et al., 2012; Nylander, Lundquist, Brännström, et al., 2009; Nylander, Lundquist, & Brännström, 2009)

According to the students, a major advantage of the OMS intervention was that it allowed them to study in places and situations where they would not normally have been able to. This is illustrated by the following quotation from one of the students: “I have not used my books for anything this week, and yet I have studied using the chemistry program without it taking any of my time.” Another opinion was that the solution was a good one because it promoted regular study habits.

The size of the phone was not considered a problem in this case, indeed it was considered to be a positive aspect in crowded places. This indicates that if the content is well-suited for the small screens of a mobile phone, the size of the screen does not matter.

Problems identified: The major problem identified was that basing the positioning on cell-based positioning was often too imprecise. This could lead to the triggers being fired too late or in incorrect situations.
Later iterations: A follow-up student thesis was initiated and supervised by me that examined the use of flashcards on mobile phones for vocabulary studies among 45 high-school students (Cedergren & Hellman, 2012). This study confirmed that commuting was the primary situation in which they chose to study, but they also used the OMS system spontaneously in unpredicted situations when they were either waiting or bored. The possibility to study in unpredicted situations was seen as a major benefit because they always carried their phones with them. A major obstacle was if they were required to enter the content of the flashcards themselves, and they preferred lists of cards supplied by the teacher. This would be a way to increase simplicity as suggested in the FBM.

Recent developments: Positioning technologies on mobile phones have evolved dramatically since the time of the study, and now much more exact location-based reminders can be triggered without using up too much of the battery. Both current major mobile operating systems now also have location-based reminders as integrated parts of the operating system. Furthermore, there are now several flashcard apps available making it easy to use a combination of location-based reminders and a flashcard app in real educational settings.

Reflection: Fogg (2009), Steel (2006), and Duhigg (2012) have all identified automation or habits as a strategy to get people to perform a target behavior, such as to study in OMS situations. In Duhigg’s work on how to create habits, a key is to identify a clear cue that can trigger the habit. In this paper, clear cues for such an automated behavior were the locations chosen as suitable for studying by the students themselves. That the students choose the locations themselves is consistent with the autonomy principle of self determination theory (Werbach & Hunter, 2012, location 714) where a feeling of making choices yourself and being in control is highly important. The locations were used to fire signal triggers, which in general led to the desired target behavior of studying, and this could be the start of a self-reinforcing feedback loop as in Duhigg’s model.

Contribution: The main contribution of paper IV is the suggested design of both position-based study reminders and the use of flashcards for memorization of suitable content in OMS situations. The evaluation showed that the students in general both appreciated and used the system as intended. They felt that it was useful and allowed them to study in
situations where they had not been able to study before. They also believed that the signal trigger reminders had triggered them to study more than if the signal triggers had not existed.

Another contribution was the confirmation that inter-time when traveling by public transportation was the most popular context for this group to get reminders to study because it was considered a time slot when they did not do anything “useful” anyway. These reminders were not seen as disturbing. However, reminders occurring at inconvenient moments were considered negative, again suggesting the importance of well-timed triggers.

**My contribution to the paper:** This paper was a collaborative effort between me and a student writing her master thesis. As in paper II, the initial idea was mine, the design was done collaboratively, and the implementation was done solely by the student. The data collection was done by the student and the analysis was a collaborative effort. The paper was written solely by me.
4.5 PAPERS V-VI


Introduction: These two short papers differ from the other papers in this thesis in that the intervention is more aimed at a pedagogical intervention focusing on helping students overcome procrastination. The audience of the papers was teaching practitioners and the texts were limited to three pages, so some extended results from the studies are presented here. Only the parts of the interventions that are relevant to OMS are described as are the contributions on the extent and reasons for procrastination, which are relevant for this thesis. In this presentation, the two papers are seen as two iterations within the same problem domain.

Background: The idea for these studies evolved slowly over a number of years. One input was the interest from students of being reminded of tasks they could easily write down in a calendar or handle themselves, as the results from papers I and IV indicated. The other input was from a seminar series running over several years (Hedin, 2009) where students had assignments in which they were to reflect on their own studying and how it could be improved. A repeating pattern was that the students stated that they had not started studying “for real” in the courses they had just taken until very late in the course. They committed, therefore, to start studying earlier in the next course, but during the next seminar they once again had failed in that intention. The realization started to grow that human rationality, as expressed, for example, in the Rational Choice Theory as discussed in section 2.5, was in doubt and that this was especially true for students who against their better judgment often chose not to study even if they knew they would be worse off for doing so. This sparked an interest in motivation theories, decision theory, gamification, distractions, behavioral economics, and designing for behavioral change.

A student thesis was initiated and supervised by me (Hindskog & Jarl, 2010) of which one part was to analyze the student reflections from the seminar course mentioned above more thoroughly. It was confirmed that a recurring theme was that the students wanted to improve their study
skills by starting studying earlier and spacing their studying more evenly throughout their courses and to get help planning their studying.

This led to the intervention in paper V that consisted of a course module where the students would learn more about procrastination, reflect and discuss procrastination with peers, and complete an assignment of making an intervention to change a bad habit or start a good habit. Paper VI was the next iteration where there was a clearer focus on changing study-related habits instead of just any habit. Paper VI also included the addition of email reminders because the results from paper V showed that many students forgot about their commitments to change procrastination behaviors and other habits. One research perspective motivating the study was to find out how much of a problem procrastination was for this group of students, and the second research perspective was to find out if an intervention could be designed that helped students change habits and to maintain their chosen habits.

**Design principles:** These two studies had less of a focus on designing for OMS and more of a focus on a pedagogical intervention for changing procrastination behavior. However, one part of the design in paper V was aimed at behavioral change by creating or changing a habit for 30 days using the motivation and trigger categories from the FBM discussed in section 3.3. The first design choice was to have the student make one or several written commitments to try to change or modify a habit of their choice. Making a commitment makes it much more likely to act consistently with that commitment according to the consistency principle (Cialdini, 1993, location 970). Second, the commitments were also made to the other students in the group. Making the commitments public, in this case to friends, further increases the chances to act consistently with the commitment (Cialdini, 1993, location 1327). The third design choice was to make the progress of these commitments visible to the other students in the group on a voluntary basis by logging success or failure in a shared spreadsheet. Making the results of the public commitment visible could also spark a competitive motivation – both to compete against yourself and to compete with others – and these can both be strong motivators according to gamification principles (Werbach & Hunter, 2012, location 652). All of the design choices above relate to increasing the motivation aspect in the FBM. Furthermore, the spreadsheet would act as a trigger in the FBM because it would show up at the top of the students’ shared documents every day. In paper VI, email
reminders were used as signal triggers based on the results of the previous studies in paper I, IV, and V because it was not possible to use shared spreadsheets for following up results in that course.

**Intervention:** The intervention consisted of the activities described above and was part of the course module on procrastination. The other pedagogical parts of the intervention are not relevant for this thesis, and interested readers are, therefore, referred to the original papers. A screenshot of the logging spreadsheet is shown in Figure 11. This logging spreadsheet falls into the span categories in the Fogg Behavior Grid described in section 3.3 because it involves performing a behavior during a period of time. The flavors varied with examples of blue (doing the familiar behavior of taking the stairs instead of the elevator), purple (increasing the behavior of studying), gray (decreasing the behavior of sleeping too late in the morning), and black (stopping the behavior of buying candy). The efforts in paper VI, where the students were to change a study habit, also fell into the various span categories because the study habits were followed up over the duration of the course. However, the aim was to move into the path categories and to make these changes permanent.

**Evaluation:** The evaluation of paper V was done using questionnaires and the reflective documents the students wrote. Because these were mandatory activities, the reply frequency among the approximately 220 students was very close to 100%. Paper VI, with 466 students, was
evaluated using questionnaires only and also had a reply frequency close to 100%.

**Results:** The results from the questionnaires regarding procrastination showed that procrastination was a very common problem. Only 5% did not have any problems with procrastination and 41% saw procrastination as a big or very big problem. A total of 83% procrastinated using at least one computer-related activity often or very often.

For the design intervention in paper V – to help students change a habit – the sample group that participated in this particular intervention was too small to draw any definite conclusions. However, for the small group of six students who did try logging their habits the results indicated very clearly that students remembered their commitments. The statistics are not presented in the paper itself, but five of the six participants did not fail to report one single applicable day since their first report (this ranged from 25 days to 33 days because some started late and some started early), and for the entire period only 33 out of a total of 521 possible reportings were omitted, or 6%. Failure to act according to the commitments was recorded 57 times, or 11%, and success was reported 431 times, or 83%.

The use of technology for procrastination was also examined. A total of 83% of the students procrastinated often or very often using at least one of the 17 e-procrastination categories available, and video was the most common. In the first group, 66% of the students (n = 218) procrastinated using mobile phones often or very often using at least one of the categories suggested, and texting, email, and Facebook were the top choices.

The intervention in paper VI – where the students made study habit-related commitments instead of any commitment of their choice – showed that 89% had at least sometimes forgotten about their commitment. For 39% of the students, the reminders had caused them to resume their forgotten habits. Only 1% were explicitly negative to reminders.

**Reflection:** One of Steel’s four categories for interventions against procrastination tendencies is sensitivity to delay of the rewards (Steel, 2007). Removing distractions by imposing stimulus control is one of the main suggestions (ibid). These studies show that distractions are a major challenge for OMS because mobile devices are an abundant source of
possible temptations and stimuli in the form of social media, video, chat, email, SMS, and so on. For computers, there are now several tools to impose restrictions on stimuli such as Freedom\textsuperscript{4}, Anti-Social\textsuperscript{5}, Cold Turkey\textsuperscript{6} and SelfRestraint\textsuperscript{7}. Using these software packages, students can voluntarily shut down certain services and sites, such as email and Facebook, but so far similar solutions are very scarce for mobile phones. AppDetox\textsuperscript{8} is one example where users can turn off apps of their choice for a duration of their choice.

The reasoning above is focused on countering procrastination tendencies. However, the results from these papers and from previous research show that procrastination is still one of the most prominent aspects in determining when students are motivated to study. This can be turned into an advantage to counteract some of the problems encountered in paper I and paper IV where reminders were sent at moments when students were less motivated to study. If the reminders could instead be associated both with a specific location, as the results from paper IV suggest, and with a time close to a deadline or to a moment when the material will be relevant, as can be determined by Temporal Motivation Theory, the motivation would then be much higher and, according to the FBM, be much more likely to make a target behavior happen.

**Contribution:** The first contribution of these papers is not within design science but rather empirical science. The procrastination for this group of students is as high as in international studies of procrastination, which due to the high number of participating students and the reply frequency are very reliable results. From an OMS perspective, this has design implications because it supports the assumption that Temporal Motivation Theory ought to be relevant for determining when students are motivated to study using OMS. Further, and with equally high reliability, the results show that computers and mobile devices are common “tools” for procrastination, which will be a challenge for OMS because distractions on a mobile phone are always just a click away. The results that the students easily forget about habits they want to create,

\textsuperscript{4} http://macfreedom.com/
\textsuperscript{5} http://anti-social.cc/
\textsuperscript{6} http://getcoldturkey.com/
\textsuperscript{7} https://github.com/ParkerK/selfrestraint
\textsuperscript{8} http://www.appdetox.net/
and that reminders can make them come back on the right track, is hardly revolutionary but supports the design idea that reminders can be useful to form habits. Finally the “gamification” used in paper V for changing habits showed much promise and is worth exploring further. If a group of students could be committed to make similar commitments for how and when to use OMS, the probability of acting on these commitments could increase.
5 CONCLUSIONS AND DISCUSSION

The aim of this thesis has been to explore how the opportunistic use of mobile devices for studying in higher education can be designed for. The iterations described in this thesis have all individually contributed knowledge of this, and these contributions were all discussed at the end of the description of each paper in chapter 4. In this chapter I take a holistic view and draw conclusions from all of the iterations combined. These conclusions are presented first as contributions to the research community where the research questions are discussed. Next the results are targeted as suggestions and recommendations to management, teachers and students. Finally, the results are reflected upon and possible future research directions are covered.

5.1 DESIGNING FOR OMS ADOPTION

The first research question was:

RQ1: How can OMS be designed to support students in adopting the behavior of studying at opportune moments?

If there were plenty of efficient options for studying in OMS situations, then in the best of worlds the students would make well-informed choices of exactly if, when, and what to study in OMS situations. However, people in general are not as rational as they might want to be and often need help to reach their goals. This is where a designer of OMS systems and activities can be of help, and this section covers the contributions and suggestions in response to the first research question.

I have used the FBM as a starting point. In this model, the target behavior to aim for is “studying at opportune moments”. In order for the target behavior to occur, three conditions are important and should occur at the same time. The student must be motivated, the student must have the ability to perform the behavior – which must also be considered simple enough to be performed at the moment – and finally a trigger can be the final tipping point to turn the intent into action. All three of these parameters were found to be important within the work of this thesis, and based on previous research and the studies in this thesis, the following conclusions are drawn and suggestions are made. The words motivation,
*simplicity, ability, and trigger* will be written in italics below to emphasize the relation to the FBM.

A general model for determining when students are sufficiently *motivated* to study can take advantage of the fact that almost all students procrastinate, as discussed in papers V and VI, and that students often choose to study later rather than sooner. The Temporal Motivation Theory provides a useful model for when a specific studying activity in OMS situations will be more appealing than the alternatives. Using this model, the moments when students will likely be interested in certain content and activities can be estimated. This can be used as a basis for a system aiming at increasing *simplicity* by providing *facilitator triggers* that can suggest relevant content by default and by generating *signal triggers* that notify the students of the availability of content they might find interesting.

To have the *ability* to study, you need to have time to study. Many opportunities occur during a part of the day when you have a few minutes available, and those times when you pull out a mobile phone because you are bored could be especially useful for OMS. However I would like to emphasize commuting as an especially good opportunity for a number of reasons. First, people in general spend a significant amount of time commuting as discussed in the introduction. Second, the results from papers III and IV in this thesis indicate that many students think commuting is a good opportunity to study, and mobile phones are very often used in these situations anyway. Third, it is relatively easy for a system to identify when a student is commuting and thereby to send *signal triggers* as was done in paper IV. Fourth, commuting provides a clear cue and occurs regularly, which makes it easier to form a habit of studying or, using the terminology of FBM, to automate the behavior. This is suggested as a key *simplicity* factor in the FBM and a way to counter procrastination in Temporal Motivation Theory.
Another opportunity when students have the ability to study is when they are bored. Indeed, being bored is one of the main reasons for using a mobile phone (J. Clark, 2010; Wroblewski, 2011), and if the routine could be changed from launching the Facebook app — or whatever the flavor of the day is — into studying, as illustrated in Figure 12, a significant step towards the adoption of OMS would have been made. A possible way to implement this is discussed below in the future work section.

Unless studying in OMS situations has become an automated behavior, which is a part of the simplicity aspect discussed above, triggers are good tools to help students start studying and can also serve as a first step towards automating the behavior. The results of paper IV and, to some extent, paper I showed that untimely triggers, where the students did not have the ability to study or the motivation to study, would serve as inverted spark triggers and could become demotivating. Well-timed triggers on the other hand, when the students had both the ability and motivation to study, served as positive signal triggers and actually triggered the students to study in OMS situations. The suggestion for designers who want to provide signal triggers is to use cell phone positioning, based on places where the students have actively indicated they would like to study, to estimate when students have the ability to study and to use Temporal Motivation Theory to determine which activities the students will be sufficiently motivated to do. If there are suitable activities at these moments, then the system should send a signal trigger by providing the list of suggested activities, otherwise the system should remain silent.

As for the interface and content, a simple functional interface is important so that the students can quickly start studying when a signal is sent. One-click delivery, as suggested in paper I, is recommended to increase simplicity. An ability aspect is that the content should be sufficiently short to be able to be studied in the often limited time...
available for OMS. Longer content can be divided into shorter units, and quick navigation between the parts – such as in the enhanced podcasts in paper III – helps students quickly find parts they want to study, and this increases simplicity. Reading longer texts was also considered non-simple, again pointing to the benefit of short learning units.

5.2 DESIGNING FOR OMS EFFICIENCY

The second research question was:

RQ2: How can OMS activities and content be designed to support efficient studying in OMS situations?

This research question has been approached with the assumption that many OMS situations are short and fragmented. Based on previous research and on the findings in papers I, III, and IV in this thesis, it is suggested that efficient activities include preparing for upcoming study sessions and repeating previous study sessions, both of which enhance the effect of studying that is done in more traditional settings.

Short introductions to upcoming lectures in the form of advance organizers were appreciated and used, as shown in paper I. They are short enough to fit into short time-slots and are, according to previous research, an efficient use of study time (Luiten et al., 1980; Stone, 1983). The same advance organizers can, if designed as in paper I, be used for repetition purposes as well, which was the case for about half of the reading events recorded in the paper. Creating and delivering advance organizers to students can be as easy as a teacher writing a blog post, and this is important because the simplicity factor from the FBM must also be considered for the teachers who provide the study material.

Another tool for repetition that was appreciated and is, according to other research, effective is the use of flashcards. They have the significant advantage that efficient studying can be accomplished even if only a few seconds are available, and they have the advantage that they are very suitable for mobile phones. In order to increase efficiency, spaced repetition algorithms can be used to determine which cards should be practiced at a particular moment, as shown in paper IV. In order to increase the simplicity for the students, they could receive complete decks of flashcards, presumably from the teacher, rather than entering the flashcards themselves (Cedergren & Hellman, 2012). However, it should
be noted that studying flashcards primarily supports rote learning – which is useful only in certain kinds of learning – and this limits their usefulness as general studying tools.

Longer studying activities can also be possible if the content is suitably divided into small, relatively self-contained pieces. In this case, it is also very important to easily be able to navigate the material. The enhanced podcasts used in paper III, which were chunked into small pieces, were good examples of this.

A technique that can be used for studying short text-based content is RSVP. For a relatively large amount of respondents, this technique was found to be equally or more appealing than scroll-based reading and was also found to be much more efficient in terms of learning per unit of time. However, it should be noted that not all kinds of texts are suitable for RSVP and that newer phone models are much better suited for reading text as discussed in paper II.

5.3 OMS FROM A MANAGEMENT PERSPECTIVE

If OMS leads to students taking advantage of more opportunities to study efficiently, it could lead to both better study results and more satisfied students and, therefore, is of interest to education management. One important aspect for management to consider will be the simplicity factor of the FBM. This will need to be considered from a student point of view but perhaps even more from a teaching point of view because enacting change in academic environments can be particularly challenging (Garrett & Davies, 2010).

One important step would be to support making content produced by the teachers easily available on mobile devices. Management can assist in this by providing an infrastructure and recommendations to ensure that the content works well not only on web or paper, but also on mobile phones. For example, OMS systems should avoid providing content as files that need external applications to view, as was the case in parts of paper I, and should provide the same content as responsive web pages, which with today’s technology is “simple” for a teacher to do. Another policy question for management is to increase simplicity for the students by making sure they can access the content quickly, for example, by avoiding requirements to enter login credentials in a learning management system in order to access the content.
Finally, management should provide system support for students to discover that content is available in an OMS situation and make it easily accessible for the students with a one-click solution. The SMS-based triggers with links to advance organizers in paper I, the location-based triggers with direct access to flashcards in paper IV, and the addition of links or content directly in digital course calendars as suggested in the reflection section of paper I are all examples of this.

5.4 OMS FROM A TEACHER PERSPECTIVE

For a teacher wanting to support students in using OMS, the simplicity factor of the FBM must be considered, both for the students and for the teacher. The outcome of the efforts involved should outweigh the cost (i.e., the effort should be efficient). Today, providing content adapted to work on mobile phones is simple, but as suggested in section 5.2 the content should preferably also be either short or divided into smaller parts and easy to navigate. This does not necessarily mean more work for the teacher. Advance organizers and enhanced podcasts are examples in this thesis of efficient interventions – in terms of a relatively minor effort on the part of the teacher – that open up many OMS opportunities. Of these, advance organizers are the easiest to get started with because these can be as simple as writing short texts introducing each lecture and placing them in a suitable place, for example, a digital course calendar or a blog. Producing and delivering a video lecture using narrated PowerPoint slides, as described in the recent development part in the discussion of paper III, is much easier and cheaper than to produce a professionally recorded lecture. Narrated slides are also easier to edit and update than screencasts.

If content and activities adapted for OMS exist, the next step for a teacher is to provide easily accessible information about when it will be most relevant for students to study using the content and activities as argued in section 5.1. In its simplest form, this can be as easy as providing links to relevant content and activities in the course schedule rather than as a separate list.

Finally, a teacher can support students by setting regular deadlines throughout the duration of the course. Externally imposed deadlines are effective at improving task performance (Ariely & Wertenbroch, 2002), promote regular studying, and allow TMT techniques to be used to
determine when students will be motivated to study. The bi-weekly deadlines in the course in paper III were an example of this.

5.5 OMS FROM A STUDENT PERSPECTIVE

Before starting to use OMS, students should consider if this is something they really want to do, and there could be many reasons not to. For example, available OMS situations might be scarce, irregular, or too short, which would decrease the ability factor in the FBM. Furthermore, personal preferences differ. As discussed in section 3.8, the Dunn and Dunn learning style model (Dunn et al., 1995) contains 21 elements that can affect students differently. Four of them are especially important for OMS.

Sound is the first element. Does the student prefer silence, music, or background noise while studying? If the situation is inherently noisy, like on a bus, students who study well with background noise could do well unless conversations are too clearly discernible, and students who prefer music can do well if they simultaneously listen to music through their phones, but students who prefer silence will have difficulties studying efficiently in such situations.

Design of the physical studying environment is the second element. Does the student prefer sitting at a chair or at a desk, on a couch or sofa, lying in bed or standing, or does it not matter? Because OMS situations are almost by definition in non-traditional studying environments, having too specific requirements in this area could make this kind of learning difficult if the studying environment does not provide for these requirements.

Persistence is the third element. Does the student prefer several shorter study periods with breaks in between or longer study periods? Does it take a long time for the student to get started with studying or can the student start learning immediately? Because many OMS situations are short and fragmented, requirements for long and continuous studying periods will make it difficult to use such situations efficiently.

The fourth element is the time of day. Mobile access to learning content, and the ubiquitous availability of mobile phones, makes it possible to study at times when the student’s energy levels are highest, not at times predetermined by a schedule outside the student’s control. However, in cases such as studying when traveling to and from the university, the suitability of these moments will be very dependent on
whether the student is tired or not early in the morning and on how much energy the student can muster after a long day of studying.

The first step for students should, therefore, be to determine if there actually are OMS situations and OMS activities that they would consider meaningful and an efficient use of their time. Even if no institutional support is provided for OMS, a student can make a personal OMS environment at the beginning of a course by matching digitally available content to specific times as long as that content is easily accessed on personal mobile devices. Using personal notes, as suggested in the future work section below, whether digital or analog, is a suggestion for meaningful repetition of content.

A student could also try to make a habit out of studying in OMS situations. This would be especially useful for students with problems with procrastination because it would help promote regular studying. To help build habits, cell phones could use the position-based notification triggers if the previously identified OMS situations are physical locations, or phone alarms if the student has instead identified specific times of the day they would like to study.

5.6 REFLECTION AND FUTURE WORK

There are, of course, several new possible directions to go from here. Starting with methodological considerations, further studies would be needed in order to both test the designs in other contexts and to use the designs to generate theories and empirical knowledge as discussed in section 2.2. One important step would be to test the designs on a more diverse population. The population in these studies has been young, interested in technology, studying technical subjects in higher education, mainly full-time students, and from Sweden. Other populations that could have different needs and different preferences include the following:

- Part-time students who might have full-time jobs and families and thereby have less freedom in planning their studies, and who might benefit from being able to study in unconventional situations.
- High-school students with frequent externally imposed deadlines.
- Non-technical students and subjects.
- Second-language learning where frequent practice, memorization, and repetition could be useful.
• Non-Swedish students and educational systems.

Another methodological issue would be to conduct longitudinal studies. All interventions have been one-shot interventions for the students, and in papers I, II, IV, V, and VI the students were aware that they were going to be evaluated on their participation in the OMS interventions. This makes them susceptible to the Hawthorne effect, which means that the knowledge that they were being observed could have changed their behavior and made them respond more positively to the interventions (Wickström & Bendix, 2000). This might also have been affected by the novelty effect according to which the novelty of the new technical intervention can cause increased attention and effort that will diminish after more continuous use (R. E. Clark & Craig, 1992). Longitudinal studies would help discover if these effects have played a role in the evaluations of the designs included in this thesis.

One final methodological issue would be to take advantage of new possibilities to log the use of phone usage, for example, RescueTime\(^9\) which can log all app starts and web site visits. Using this could provide insights into the situations in which the solutions are used and what effects the triggers actually have.

Turning to other possible uses of OMS, one very promising idea is to use OMS situations for reviewing personal notes. Notes have several characteristics that make them interesting. They are condensed and (hopefully) relevant, they are suitable for spaced learning and for repetition in general, and they give good effects even if studied for time intervals as short as 5–10 minutes (Kiewra, 1985). Furthermore, there is substantial evidence that reviewing notes is an efficient use of time, as shown in Kiewra’s meta-analysis of 22 note-taking studies (ibid). Digital notes would be preferred in order to be able to study anywhere and anytime due to the ubiquitous access to mobile phones and the suitability of using mobile phones in cramped conditions. Digital notes have also taken great leaps recently, for example, with the Samsung Note family of phones and tablets and the LiveScribe series of pencils \(^{10}\) that automatically digitize notes written on paper. However, reviewing ordinary paper-based notes would also be a suitable studying activity in

\(^9\) https://www.rescuetime.com/
\(^{10}\) http://www.livescribe.com/
OMS situations and would be something almost all students could do, at least when commuting to and from a university because the students’ notes are likely to be carried in these situations.

Another path is to use OMS for collective feedback on texts using social annotation systems. Research literature often suggests that feedback should be provided soon after submitting assignments (Nicol & Macfarlane-Dick, 2006), and other research shows that peer assessment using social annotation systems such as Google Docs is effective and appreciated by students (Hedin, 2012a; Pargman, Hedin, & Hrastinski, 2013). Google Docs is a useful tool for social annotations and has two important OMS related features: 1) it works as a cloud service accessible both from computers and mobile phones, and 2) it can send email notifications as soon as anyone has commented on a document. These notifications are very suitable for use as all three types of triggers suggested by the FBM. They serve as spark triggers because getting a notification that someone has commented on your text sparks an interest in seeing what it is, they serve as facilitator triggers because the email includes a direct link to the comment in the document, and they serve as signal triggers to remind you that this is a meaningful activity you can do in an OMS situation.

A less intrusive way to provide triggers or cues than to send notifications to mobile phones would be to take advantage of opportunities when people use mobile phones because they are bored. A suggestion for how this could be implemented is to use lock-screen widgets, such as those available on Android devices, because the lock-screen is viewed every time the phone is unlocked. Such a widget could regularly collect data and provide suggestions of suitable OMS activities based on Temporal Motivation Theory and display them on the lock screen, for example, as an RSS feed as shown in Figure 13.

Another idea would be to develop a recommendation system that knows what students are likely to be interested in and recommends activities based on that. Google Now already provides a similar service, but for various other purposes, and provides information such as the time to get to commonly visited places and the weather in places you have recently visited or searched for. Other recommendation services like Amazon’s book recommendations suggest content based on previous choices and the preferences of friends. If course content could be appropriately tagged with information about courses and deadlines, the
system knew which courses the student currently takes, and data were collected on what friends have read and recommended, an attractive recommendation system could likely be built.

One problem that could be explored further before promoting OMS is the stress it could generate if students choose not to study in a mobile context but feel they ought to. Up until now, there have been many situations where studying simply is not possible because the material the student could/should study is not available in the current situation. Now, as discussed in this thesis, learning activities can be easily available anywhere, anytime, thereby giving the students the option to study instead of, for example, relaxing. If the students feel they “really ought to” study in a mobile context, but choose not to, this could lead to negative stress that would not have occurred if the students did not even have the possibility to study in the same context. What is also relevant with this problem is that it could apply to all students, even those who are not

Figure 13. Left: A lock-screen trigger for studying that displays a personalized RSS-feed of suggested OMS tasks. Right: The content when clicking on the first suggested item.
really interested in learning in mobile contexts but know that the possibility exists.

Finally, only time will tell whether OMS will be an activity used by many, few or no students. There is a constant flow of new services competing for students' inter-time, so the scene might be completely different just a few years from now. In the end the choice of what to do in inter-time moments will always be up to the students, but it is my hope that this thesis can serve as an eye-opener for the possibilities of OMS for both teachers and students.
6 Bibliography


